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ENERGY FROM BIOMASS IN THE EUROPEAN UNION

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The total amount of primary bioenergy[1] production in the 27 Members States of the European Union (EU-27) was 100.77 Mtoe in 2009 and 112.73 Mtoe in 2010 respectively.

BIOELECTRICITY

Installed capacity

The total installed capacity of electricity power plants possible to be fed with raw material of renewable origin was 25.8 GW in 2008 and 28.7 GW in 2010. Nevertheless, this total installed capacity figure also includes Municipal waste treatment facilities that are usually fed with a mixture of renewable and non-renewable material and in Figure 1 this capacity is shown separately.

The overall bioelectricity installed capacity has shown in the last decade an average annual increase of about 2 GW. Even more impressively, from 2003 to 2010 the annual average capacity increase amounted to about 2000 MW/y, i.e., more than four times the annual average increase in installed capacity between 1996 and 2002 (which was around 450 MW/y).

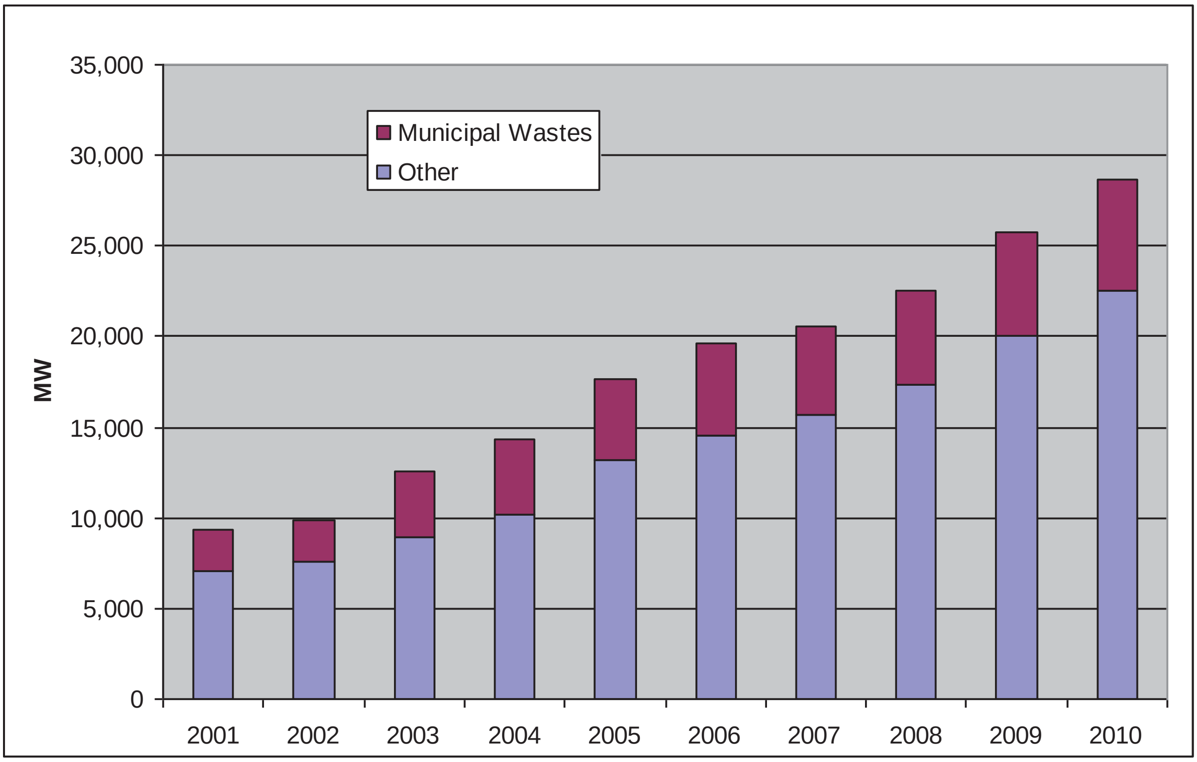

Figure 1 Total bioelectricity installed capacity in the EU-27 from 2001 to 2010

[1] Bioenergy: bio-heat + bio-electricity + biofuels for transport

Wood/wood waste represents the biggest proportion of installed capacity with 53.6 % (Figure 2) but biogas is the sector that has shown the highest percent growth rate in 2010 comparing with 2009 data: 20% of growth to be compared with 7% of wood, 10% of municipal waste and 13% of liquid biofuels.

Wood and wood waste is mostly processed in 4 leading countries (Sweden, Germany, Austria and Finland) accounting for more than 9 GW in total. Germany is also leader for electricity from biogas with 2.7 GW installed, followed by UK (1.1GW) Austria and Italy (about 0.5 GW each one).

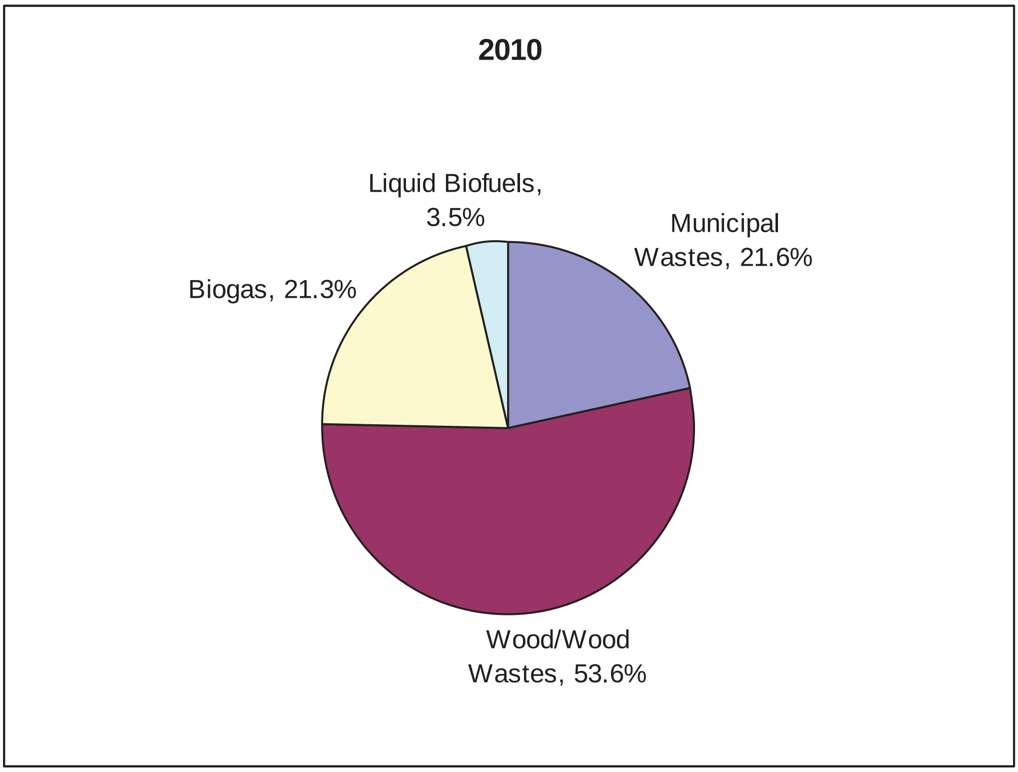

Figure 2 Installed bioelectricity capacity by source in the EU-27 in 2010

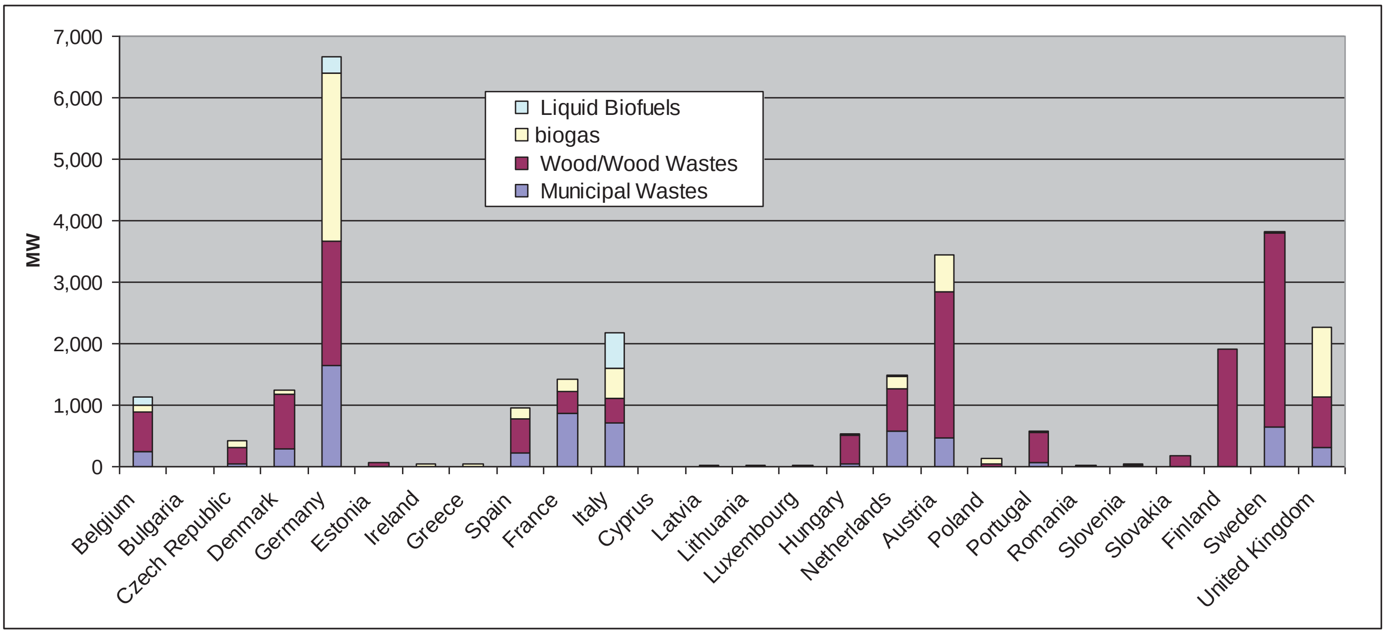

Figure 3 Bioelectricity installed capacity in the EU MS-s by source in 2010

Electricity generated

The electricity produced originating from biomass was 107 TWh in 2009 and 123 TWh in 2010 in the EU-27 with yearly increases between 10 % and 20% in the last decade (Figure 4).

Germany kept its role as the biggest bioelectricity producer in 2010 with 33672 GWh followed by Sweden and UK with 12192 and 11916 GWh respectively (Figure 5). These three countries alone represent almost half (47 %) of the total production within the EU-27 Member States.

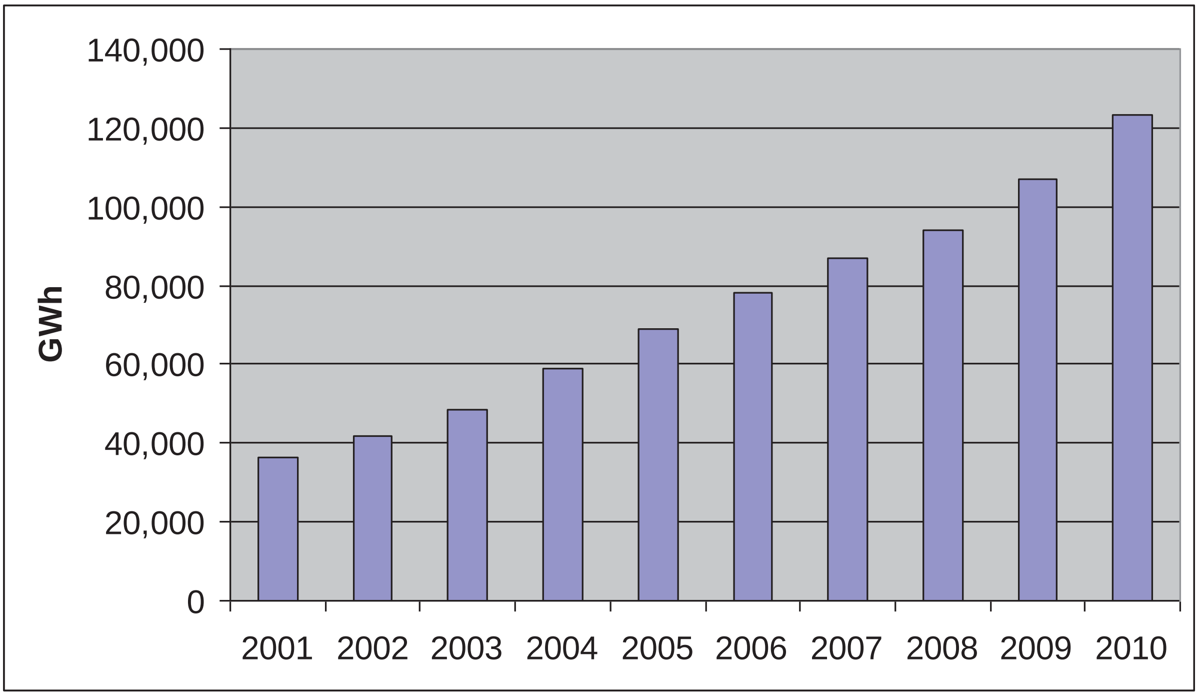

Figure 4 Bioelectricity production in the EU-27 since 2001

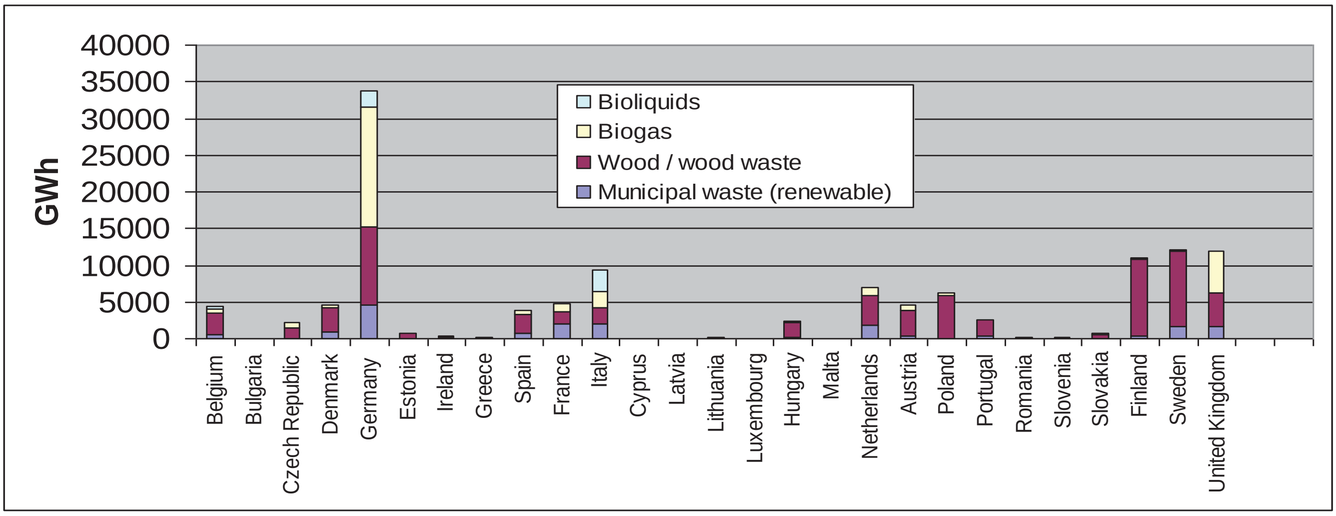

Figure 5 Bioelectricity production in the EU-27 MS-s in 2010 by categories

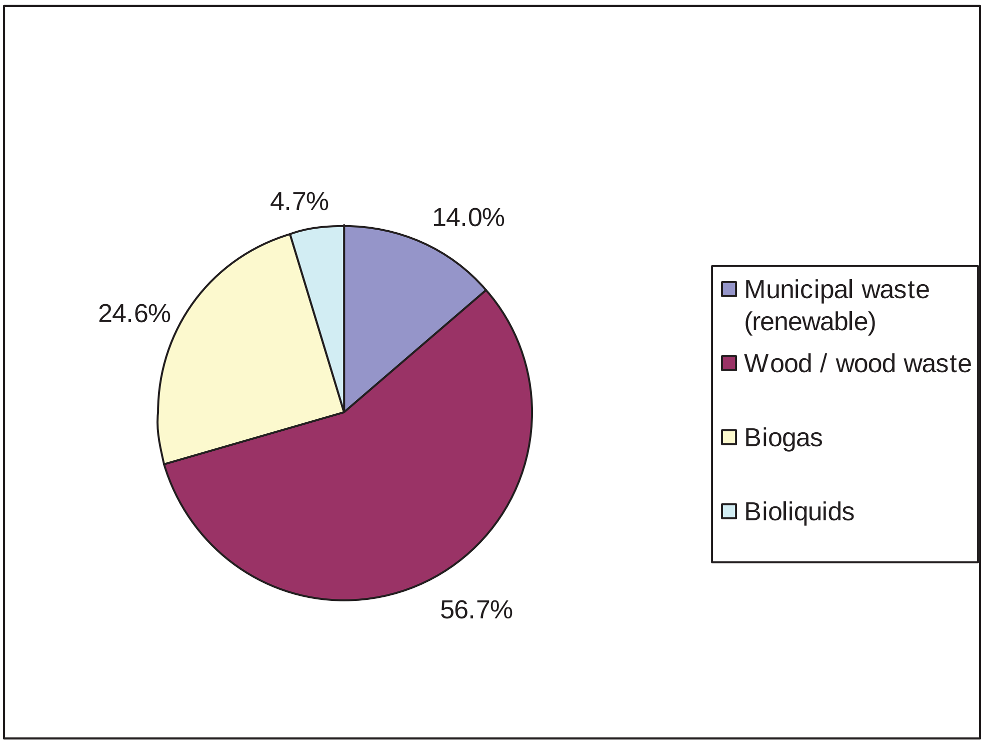

Figure 6 Bioelectricity generation from biomass in the EU-27 in 2010 by source

Wood and wood waste was also the main source of generated electricity with a proportion of 56.7 % followed by biogas (24.6 %) while the renewable fraction of municipal waste accounted for 14 % (Figure 6).
For more than half (16) of the member states the wood/ wood waste was the leading bioelectricity source, while in a smaller number of countries (Germany, Ireland, Greece, Luxembourg, UK and Latvia) biogas is the leading source of bioelectricity. .

HEAT FROM BIOMASS

Heat produced from biomass amounted to 8 Mtoe in 2009 and 9.6 Mtoe in 2010 in the EU-27 (Figure 7). The solid form is by fare the main source for the heat production from biomass in the EU-27 with wood and wood waste accounting for 75 % of the heat generated. (Figure 8).

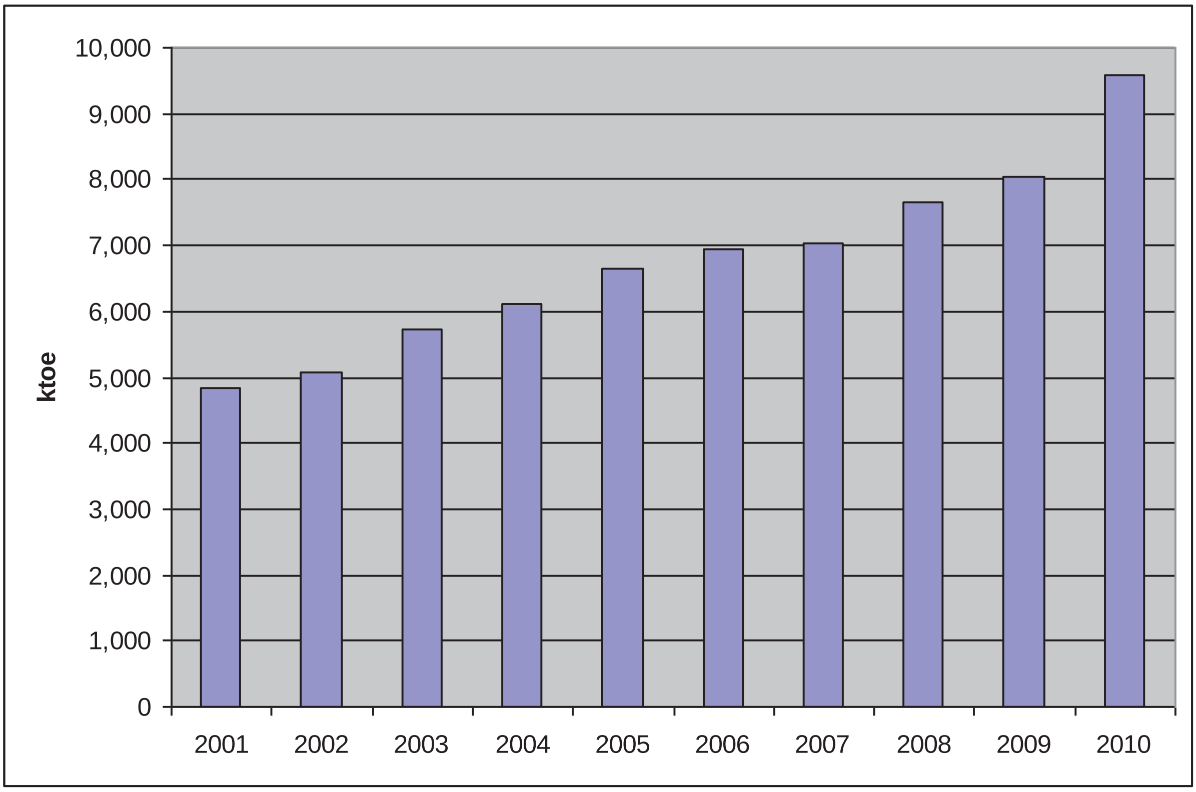

Figure 7 Heat production from biomass in the EU-27 since 2001

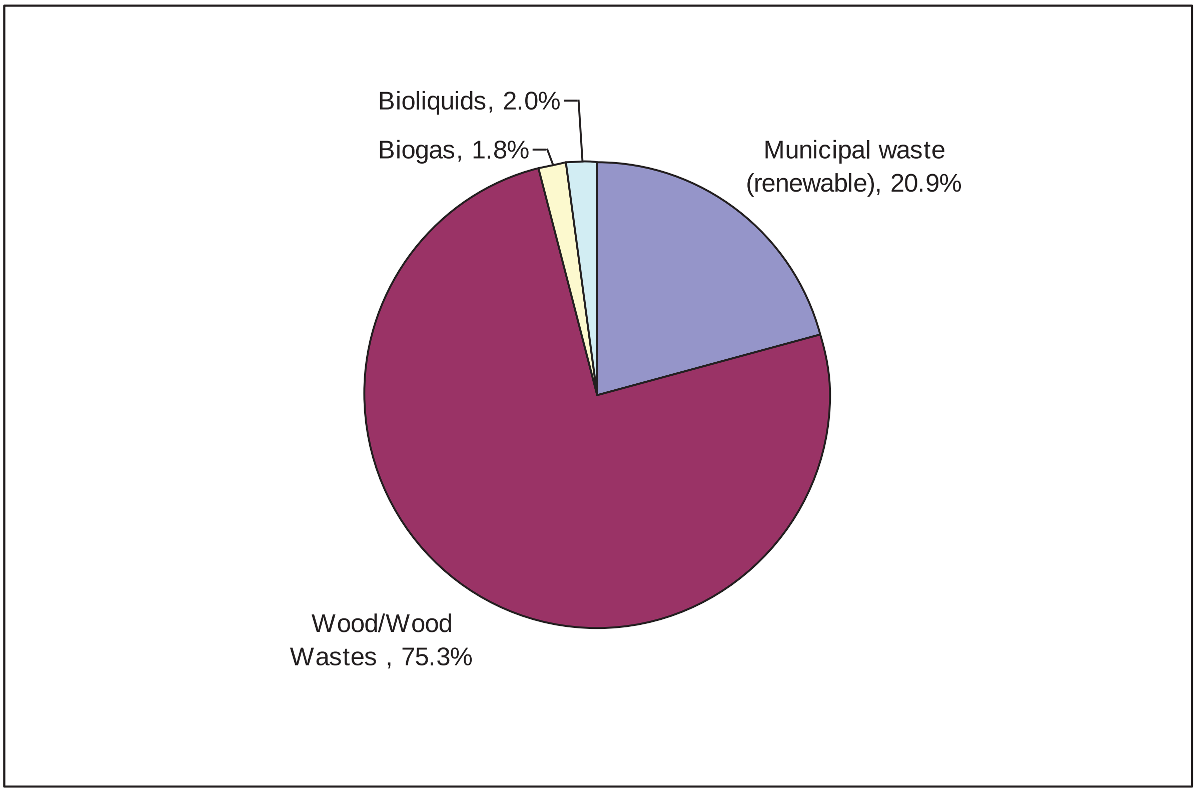

Figure 8 Bioheat production by source in the EU-27 in 2010

Sweden was the leading member state in bioheat production with 3.6 Mtoe, followed by Finland, Denmark and Germany with 1.6, 1.2 and 1 Mtoe, respectively (Figure 8). These four countries covered around 75 % of the total EU-27 bioheat production.

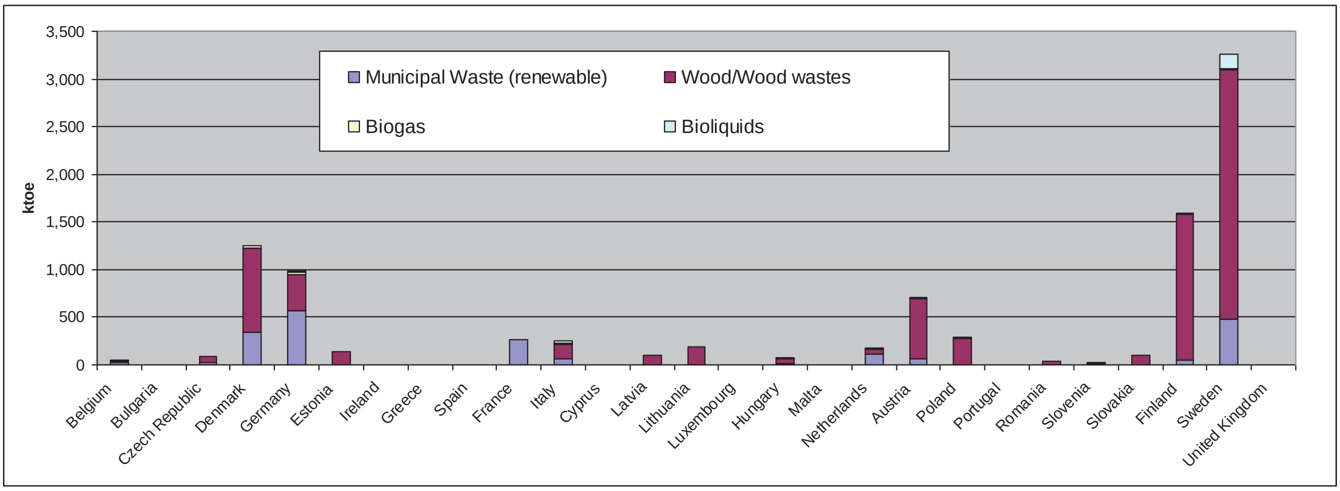

Figure 9 Bioheat production by categories in the EU-27

BIOFUELS: SOURCES AND USE

Table 1 summarizes the total flows of liquid biofuels in EU-27 in 2010.[2]

Primary production of biofuels in EU-27 amounted to a total of 13 Mtoe in 2010. The majority of the produced biofuels is biodiesel (63%) while biogasoline and other liquid biofuels contributed less (16% and 21%, respectively). Imported biofuels provided 4.8 Mtoe while 2.2 Mtoe of biofuels was exported in 2010 summing to a net import balance of 2.6 Mtoe.

Table 1: Biofuels flows in EU-27 in 2010. Data in ktoe. (Eurostat 2012)[3] [4]

	Biogasoline	Biodiesel	Other	Total
Primary production	**2021**	**8142**	**2777**	**12940**
Total imports	1058	3512	200	4771
Stock change	-3	-9	-1	-13
Total exports	405	1763	5	2173
Net imports	**653**	**1749**	**195**	**2598**
Gross inland consumption	**2672**	**9882**	**2971**	**15525**
Input to thermal power stations	0	0	1551	1551
Input to district heating plants	0	0	181	181
Final energy consumption	**2803**	**9993**	**1223**	**14018**
Final energy consumption - Industry	0	34	632	666
Final energy consumption - Transport	2799	9937	536	13272
Final energy consumption - Households	4	22	55	80
Statistical Difference	**-131**	**-167**	**0**	**-298**

[2] The not negligible statistical difference for some products shows how 2010 data still needed stabilization at the time of last update (April 2012)

[3] In the whole analysis the following biofuels products coded by EuroStat have been considered: biogasoline (5546), biodiesel (5547), other liquid biofuels (5548), biofuels (5545).

[4] Eurostat indicators: Primary production (100100), total imports (100300), stock change (100400), total exports (100500), net imports (100600) , gross inland consumption (100900), Input to conventional thermal power stations (101001), Input to district heating plants (101009), Final energy consumption (101700), Final energy consumption – Industry (101800), Final energy consumption – Transport (101900), Final energy consumption - Households/Services (101200)

Almost all biogasoline (i.e., the sum of bioethanol, biomethanol, bio-ETBE and bio-MTBE[5]) and biodiesel is used in transport sector, while a consistent amount of other liquid biofuels (mainly pure vegetable oils) are used for district heating, power generation and industry. (see figures 6 and 8)
In EU-27, Germany is the main biofuel producer with 4.6 Mtoe (35% of EU-27 production) followed by France with 2.2 Mtoe (17% of EU-27 production). Other relevant biofuels producers are shown in Figure 10.

Import/export flows for EU-27 countries are shown in Figure 11. UK imports 850 ktoe of biofuels, mainly biodiesel while Italy is the second importer with 620 ktoe. In the case of UK biofuels import is roughly equivalent to 3.5 times the domestic production while in case of Italy import accounts for about 40% of the domestic production. In the large majority of EU countries, both production and import/export flows focus on biodiesel.

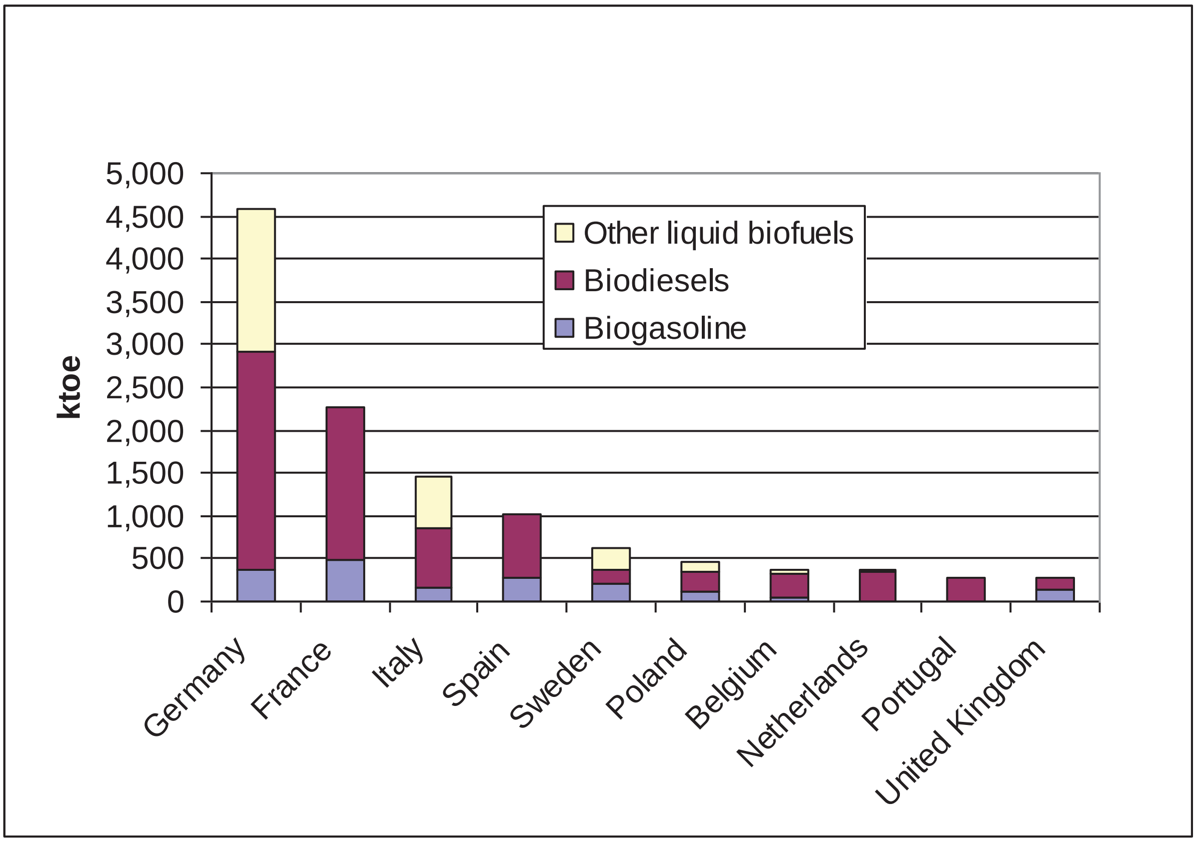

Figure 10 Relevant biofuels producer in EU-27 in 2010. Countries not included in the figure produce less than 250 ktoe [6]

[5] See Eurostat's Concepts and definition database (CODED) and definitions in Directive 2003/30/EC on the promotion of the use of biofuels and other renewable fules for transport.
[6] Eurostat indicators: Primary production (100100)

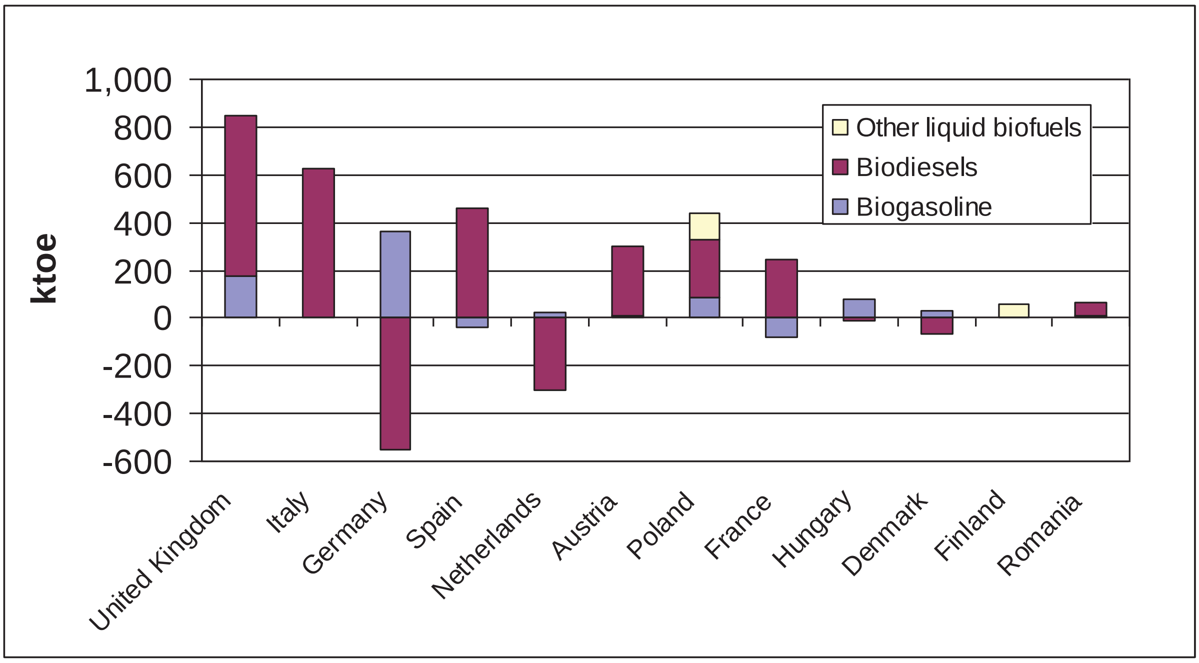

Figure 11 Relevant biofuels importers (positive values) and exporters (negative values) in EU-27 in 2010. Countries not included in the figure import and export less than 50 ktoe[7]

TRENDS IN BIOFUELS MARKET

Figure 12 shows as the production of biofuels is constantly increasing in last decade even at a slower pace since 2008. At the same time, EU-27 has moved from being a net exporter to become a net importer for an increasing amount of biofuels. Since 2008 the domestic EU-27 biofuels production has grown by roughly 10% every year, definitely less than the huge 60% yearly growth registered in 2004-2006 period. In absolute terms, the annual production increase has become stable in last three year around 1000 ktoe per year. If also imports are considered, the overall amount of marketed biofuels in EU-27 has increased by more than 2 Mtoe during the years 2006-2009 with the increase for year 2010 equal to 1.7 Mtoe leading the 2010 market expansion back to dimensions not seen since 2005.
On summary, latest trends show an overall slowing of the recent huge market expansion for biofuels in EU-27, more evident for domestic production and an increasing importance of imports from outside EU-27.

[7] Eurostat indicators: Total imports (100300), total exports (100500)

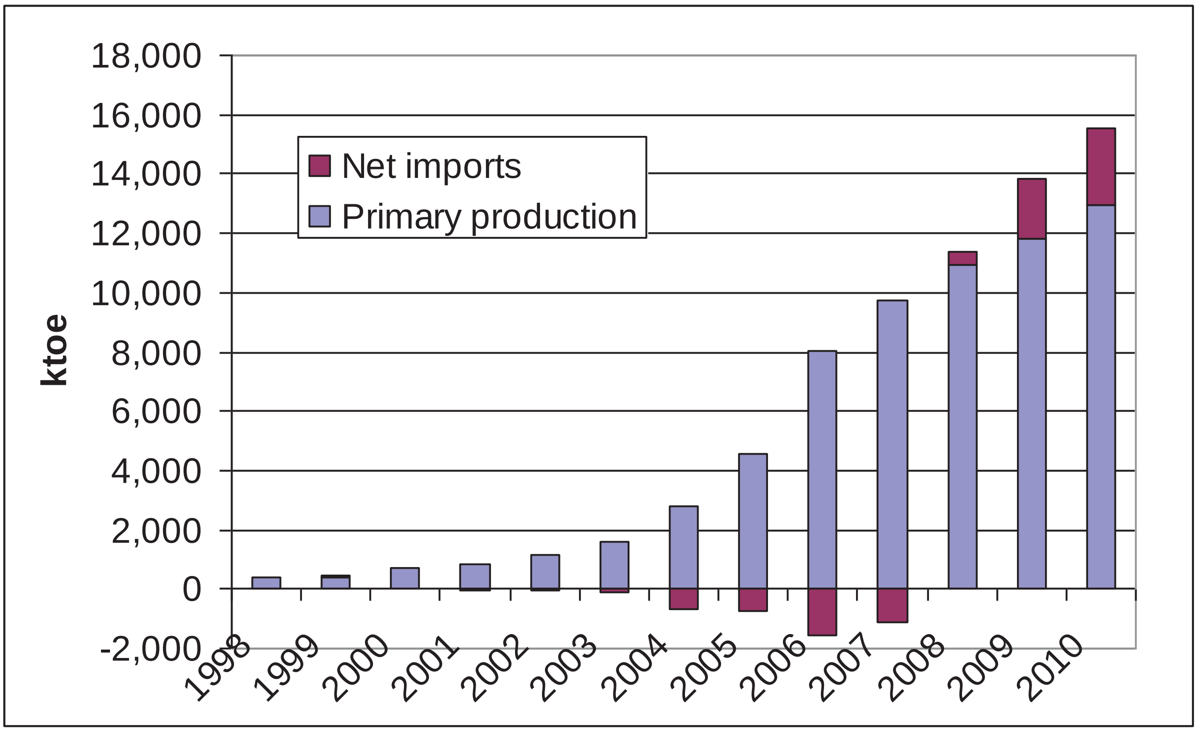

Figure 12 trends of biofuels production and imports in 1998 – 2010 in EU-27 [8]

Biofuels in transport sector

In 2010 the **consumption of biofuels** in the transport sector amounted to 13.3 MToe in EU-27. Biodiesel has been by far the most consumed biofuel with a share of 75% while biogasoline accounted for 21 % and other biofuels accounting for around 4% (see Figure 13).

Germany is still the largest consumer of biofuels in EU-27 (3 MToe with a 22% share) followed by France: 2.4 Mtoe accounting for 18 % of EU-27 consumption. Italy, Spain and UK all have a biofuels consumption share ranging between 9 and 11 percent of the whole European market.

[8] Eurostat indicators: Primary production (100100),Total imports (100300).

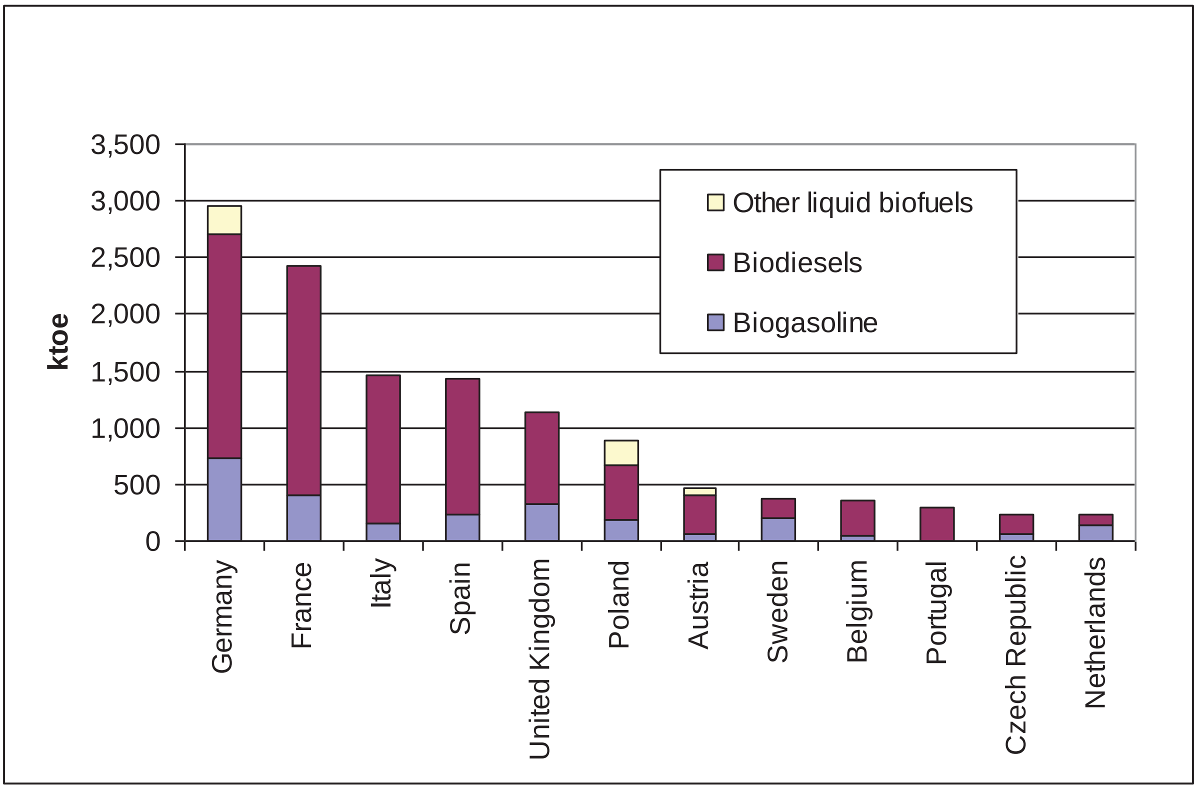

Figure 13 Final energy consumption of biofuels in the transport sector in the EU-27 in 2010 (Eurostat 2012). Countries not included in the figure consume less than 200 ktoe [9]

Figure 14 shows the **share of biofuel contribution to the overall energy consumption in transport sector** for the EU-27 countries. On average biofuels accounted for 3.6% of the energy consumed in transport in 2010 with an increase of about 0.4% in comparison with 2009 figure. Nevertheless, the situation is very diverse throughout Europe.

Slovakia (6%), Austria (5.4%), Poland (5%), France and Germany (4.8%), Sweden (4.4%) and Portugal (4%) lead the way, while all other countries are below 4%, with 9 countries not reaching the 2%, in front of a compulsory target of 10% of renewable energy in transport in 2020.

[9] Eurostat indicators: Final energy consumption – Transport (101900).

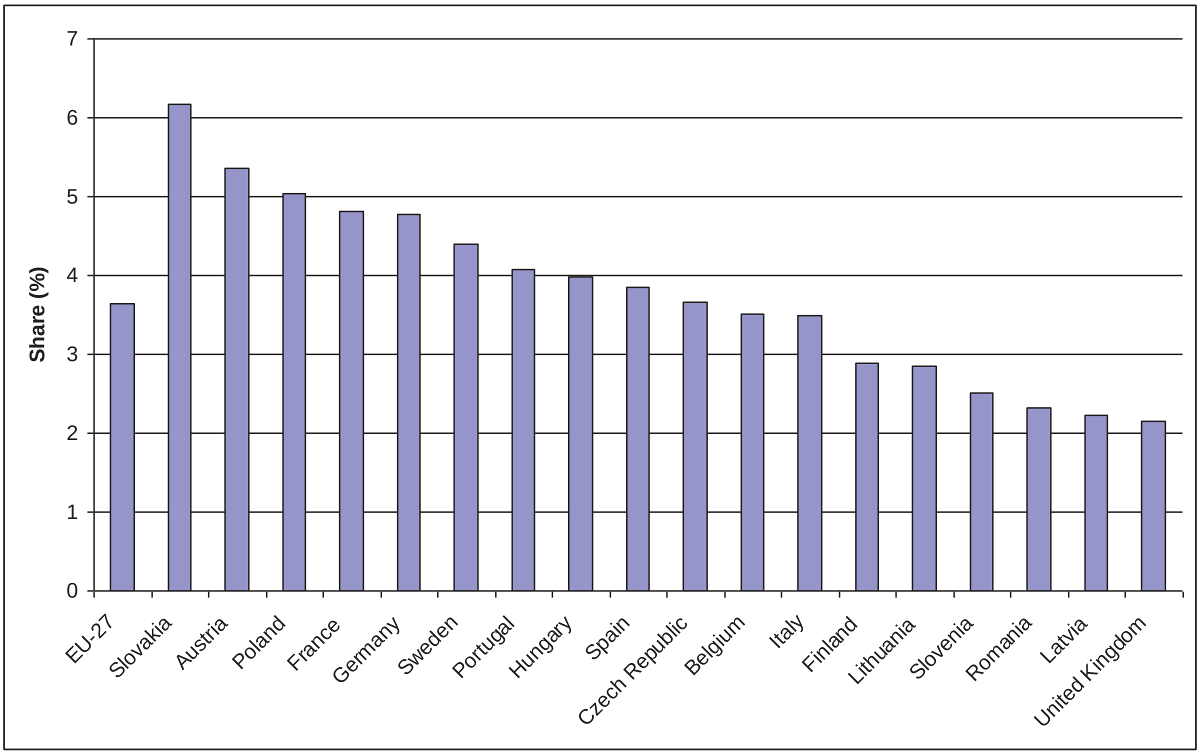

Figure 14 Share of energy consumption in transport provided by biofuels in 2010. (Eurostat 2012) Countries not shown in the figure have a biofuels share smaller than 2% [10]

References

Eurostat 2012: Data navigation tree at http://epp.eurostat.ec.europa.eu/ , last consultation September 2012.

[10] Eurostat indicators: Final energy consumption – Transport (101900) for all products (0000) and biogasoline (5546), biodiesel (5547), other liquid biofuels (5548).

CONCENTRATED SOLAR THERMAL ELECTRICITY (CSP)

SNAPSHOT 2012

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Solar thermal electric power plants are generating electricity by converting concentrated solar energy to heat, which is converted to electricity in a conventional thermal power plant. The two major concepts used today are *Parabolic Trough* power plants and *Power Towers*. Other concepts including the *Dish Design* with a Stirling engine are researched as well, but so far no commercial plant has been realised.

After more than 15 years, the first new major capacities of Concentrated Solar Thermal Electricity Plants came online with Nevada One (64 MW[11], USA) and the PS 10 plant (11 MW, Spain) in the first half of 2007. In Spain the Royal Decree 661/2007 dated 25 March 2007 was a major driving force for CSP plant constructions and the ambitious expansion plans between 2007 and early 2012 when the Spanish Government passed the Royal Decree 1/12 [1], which suspended the remuneration pre-assignment procedures for new renewable energy power capacity.

At the end of September 2012 CSP plants with a cumulative capacity of about 1.73 GW were in commercial operation in Spain about 72% of the worldwide capacity of 2.4 GW. Together with those plants under construction and those already registered for the feed-in tariff this should bring Spain's CSP capacity to about 2.5 GW by 2013. This capacity is equal to 60 plants which are eligible for the feed-in tariff.

In total projects with a total capacity of 15 GW have applied for interconnection. This is in line with the European Solar Industry Initiative, which aims at a cumulative installed CSP capacity of 30 GW in Europe out of which 19 GW would be in Spain [2]. More than 100 projects are currently in the planning phase mainly in Spain, North Africa and the USA.

The current average investment costs for the solar part are given in various projects at around € 4/W. Depending whether the plant has a backup in the form of a fossil fired gas turbine and/or a thermal storage the project costs can increase up to € 14/W.

Table 1 to 4 show the CSP plants in operation and those under construction which are scheduled to become operational until 2013. If the announced schedules are kept, the current installed capacity of about 1.5 GW should more than triple to 4.7 GW in 2013.

[11] The capacity figures given are MW_{el} (electric) not MW_{th} (thermal)

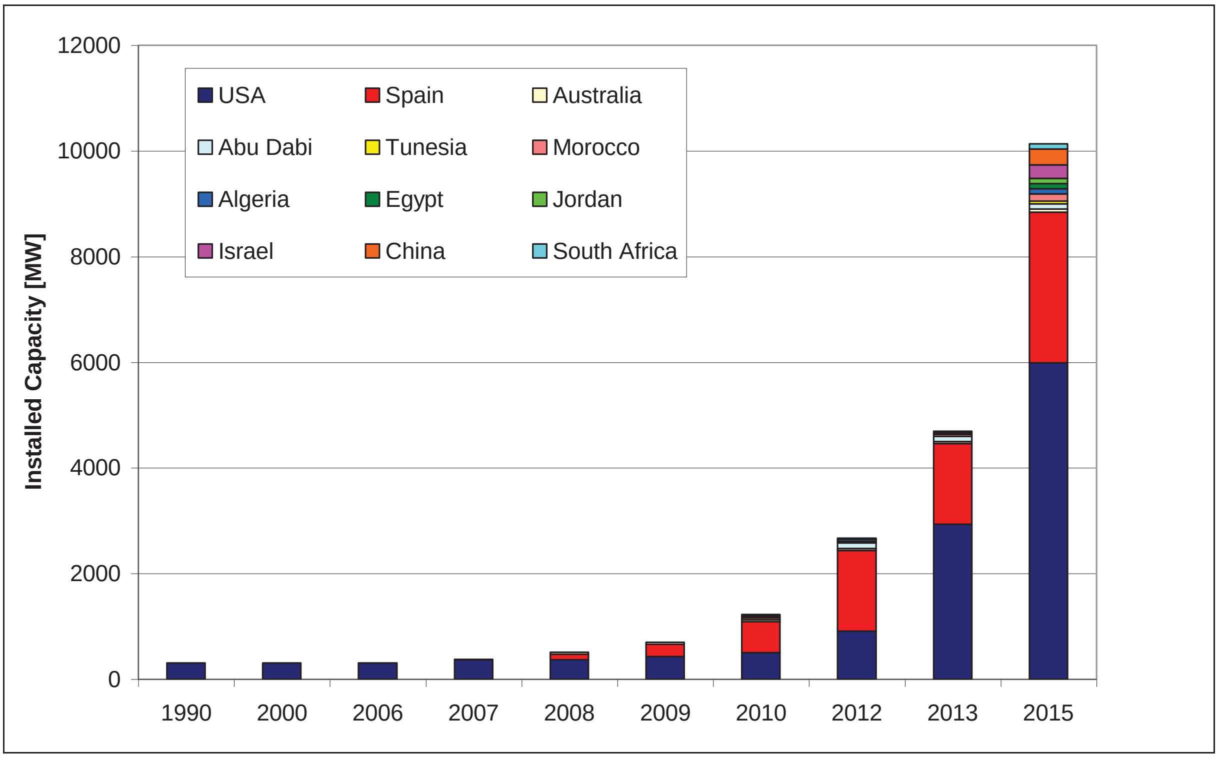

Figure 1: Installed and planned Concentrated Solar Thermal Electricity Plants [3,4,5]

Table 1: List of plants in commercial operation [3, 4, 5]

Name of Project and Consortium	Technology	Capacity [MW_{el}]	Start of operation	Investment Volume
SEGS (Mojave Dessert, CA, USA)	parabolic troughs	354	1984 - 1990	n.a.
Saguaro Solar Facility, Arizona Public Service (Red Rock, AZ, USA)	parabolic troughs	1	2006	n.a.
Nevada Solar One, Acciona/Duke Energy (Boulder City, NV, USA)	parabolic troughs	64	2007	$ 266 million
Solúcar Platform – PS 10 Abengoa; (Sanlúcar la Mayor, Spain)	tower	11	2007	n.a.
Andasol 1; Solar Millenium (Guadix, Spain)	parabolic troughs	50	2008	€ 300 million
Kimberlina Ausra; (Bakersfield, CA, USA)	fresnel reflectors	5	2008	n.a.
Liddel Power Station (Lake Liddel, Australia)	fresnel reflectors	2	2008	n.a.
Andasol 2 Solar Millenium; (Guadix, Spain)	parabolic troughs	50	2009	€ 300 million
Solúcar Platform – PS 20 Abengoa; (Sanlúcar la Mayor, Spain)	tower	20	2009	n.a.
Puertollano 1 Iberdrola; (Ciudad Real, Spain)	parabolic troughs	50	2009	n.a.

Alvarado I; Acciona (Alvardao, Badajoz, Spain)	parabolic troughs	50	2009	€ 236 million
Sierra Sun Tower eSolar; (Lancaster, CA, USA)	tower	5	2009	n.a.
Puerto Errado 1, Novatec Solar (Calasparra, Spain)	fresnel reflector	1.4	2009	n.a.
Keahole Solar Power (Hawaii, HI, USA)	parabolic troughs	2	2009	n.a.
Shiraz solar power plant, Iran	parabolic troughs	0.25	2009	n.a.
Maricopa Solar, NTR (Phoenix, AZ, USA)	dish stirling	1.5	2010	n.a.
Extresol 1 & 2; ACS-Cobra-Group/Solar Millenium AG (Torre de Miguel, Spain)	parabolic troughs + 7.5h storage	100	2010	Extresol 1, € 300 million
Solúcar Platform – Solnova 1 ,3; 4, Abengoa/Schott Solar (Sanlúcar la Mayor, Spain)	parabolic troughs	150	2010	Solnova 1 & 3, € 400 million
Archimedes, Sicily, Italy	Gas, Solar + storage	5 solar	2010	€ 40 million
La Florida, Renovables SAMCA (Badajoz, Spain)	parabolic troughs + 7.5h storage	50	2010	n.a.
Hassi-R'mel I; Algéria (Sonartrach/Abener)	Solar Combined Cycle	150 total, 35 solar	2010	€ 320 million
Ain-Ben-Mathar, Morocco (Abengoa/ONE)	Solar Combined Cycle	470 total, 35 solar	2010	€ 469 million
Yazd Solar Thermal Power Plant, Iran	Solar Combined Cycle	467 total 17 solar	2010	n.a.
Palma de Rio II, Acciona (Palma del Río, Spain)	parabolic troughs	50	2010	€ 251 million
Majades I, Acciona (Majadas de Tiétar, Spain)	parabolic troughs	50	2010	€ 237 million
Martin Next Generation Solar Energy Center, FPL (Indiantown, FL, USA)	ISCC	75 solar	2010	$ 480 million
La Dehesa, Renovables SAMCA (La Garrovilla, Spain)	parabolic troughs + 7.5h storage	50	2011	n.a.
Lebrija-1, Solel/Sacyr (Lebrija, Spain)	parabolic troughs	50	2011	$ 400 million
Manchasol 1 & 2, ACS/Cobra Group (Alcazar de San Juan, Spain)	parabolic troughs + 7.5h	100	2011	n.a.

	storage			
Kuraymat; Iberdrola/Mitsui/Solar Millenium; (Kuraymat, Egypt)	Solar Combined Cycle	150 total, 25 solar	2011	solar part: 4,935 $/kW.
Gemasolar, Terresol Energy (Fuentes de Andalucía, Seville, Spain)	Solar tower with molten salt storage	20 (6,500h/a	2011	€ 240 million
Palma de Rio I, Acciona/Mitsubishi Corp. (Cordoba, Spain)	parabolic troughs	50	2011	€ 240 million
Helioenergy 1 Abengoa (Écija, Sapin)	parabolic troughs	50	2011	€ 275 million.
Andasol 3; Solar Millenium AG (Spain)	parabolic troughs; solar (90%) + gas + thermal storage	50	2011	€ 300 million
Valle 1 & 2; Torresolar (San Jose de Valle, Spain)	parabolic troughs + 7h storage	100	2011	€ 660 million
Helioenergy 2 Abengoa (Écija, Spain)	parabolic troughs	50	2011	€ 275 million
El Reboso II, Bogaris (La Puebla del Río, Spain)	parabolic troughs	50	2011	€ 220 million
Victorville 2 Victorville, CA (USA)	gas fired + parabolic troughs	553 total with 50 solar	2011	$ 450 million
Thai Solar Energy 1, (Huai Kachao, Kanchanaburi Province, Thailand)	parabolic troughs	5	2012	n.a.
Aste 1A & 1B1 (Alcázar de San Juan, Ciudad Real, Spain)	parabolic troughs + 8h storage	100	2012	n.a.
Puerto Errado 2 (Calasparra, Spain)	fresnel + 0.5h storage	30	2012	n.a.
Solacor 1 & 2 (El Carpio, Córdoba, Spain)	parabolic troughs	100	2012	n.a.
Helios 1 & 2 (Puerto Lapice, Ciudad Real, Spain)	parabolic troughs	100	2012	n.a.
Solaben 2 & 3 (Logrosan, Spain)	parabolic troughs	100	2012	> € 500 million
Moron (Morón de la Frontera, Sevilla, Spain)	parabolic troughs	50	2012	n.a.
Guzmán (Palma del Rio, Córdoba, Spain)	parabolic troughs	50	2012	n.a.
Total (October 2012)		**2,414.15**		

Table 2: List of projects currently under construction with projected operation [3, 4, 5]

Name of Project	Technology	Capacity [MW_{el}]	Start of construction and/or operation	Investment Volume
Casa se los Pinos (Casa se los Pinos, Spain)	Parabolic Dish	1	behind schedule	n.a.
La Africana (Palma de Rio, Spain)	parabolic troughs	50	Construction 2011 Operation 2012	n.a.
Olivenza 1 (Olivenza, Spain)	parabolic troughs	50	Construction 2011 Operation 2012	n.a.
Orellana (Orellana, Spain)	parabolic troughs	50	Construction 2011 Operation 2012	n.a.
Thermosolar Borges (Borges Blaques, Spain)	parabolic troughs + biogas	22.5	Construction 2009 Operation 2012	€ 150 million
Extresol 3; ACS-Cobra-Group (Torre de Miguel, Spain)	parabolic troughs + 7.5h storage	50	Construction 2009 operation 2012	€ 300 million
Shams 1 (Madinat Zayed, UAE)	parabolic trough	100	Construction 2010 Operation 2012	$ 600 million
Solaben 1& 6 (Logrosan, Spain)	parabolic troughs	100	Construction 2011 Operation 2013	> € 500 million
Termosol 1 (Navallvialr de Pela, Spain)	parabolic troughs + 9h storage	50	Construction 2011 Operation 2013	n.a.
Cáceres, (Galisteo y Valdeobispo, Spain)	parabolic troughs	50	Construction 2011 Operation 2013	n.a.
Kogan Creek (Kogan Creek, Australia)	Fresnel	44	Construction 2011 Operation 2013	n.a.
Godawari Solar Project (Naukh, India)	parabolic trough	50	Construction 2011 Operation 2013	n.a.
Agua Prieta II (Agua Prieta, Mexico)	parabolic trough	14	Construction 2011 Operation 2013	n.a.
Abengoa Mojave Project (Harper Dry Lake, CA, USA)	parabolic troughs	250	Construction 2010 Operation 2013	n.a.
Ivanpah 1, 2 & 3, Ivanpah Solar, San Bernardino, CA (USA)	solar tower + gas-fired start-up boiler	370	Construction 2010 Operation 2013	n.a.
Total		**1,251.5**		

In December 2009 the World Bank's Clean Technology Fund (CTF) Trust Fund Committee endorsed a CTD resource envelope for projects and programmes in five countries in the Middle East and North Africa to implement CSP [6]. The budget envelope proposes CTF co-financing of $ 750 million (€ 600 million[12]), which should mobilize an additional $ 4.85 billion (€ 3.88 billion) from other sources and help to install more than 1.1 GW of CSP by 2020.

[12] Exchange rate 1 € = 1.25 $

As a follow up to this initiative, the World Bank commissioned and published a report early 2011 about the Local Manufacturing Potential in the MENA region [7]. The report concludes: *MENA could become home to a new industry with great potential in a region with considerable solar energy resources. If the CSP market increases rapidly in the next few years, the region could benefit from significant job and wealth creation, as well as from enough power supply to satisfy the growing demand, while the world's renewable energy sector would benefit from increased competition and lower costs in CSP equipment manufacturing*.

Within just a few years, the CSP industry has grown from negligible activity to over 3.5 GW_e either commissioned or under construction. More than ten different companies are now active in building or preparing for commercial-scale plants, compared to perhaps only two or three who were in a position to develop and build a commercial-scale plant a few years ago. These companies range from large organizations with international construction and project management expertise who have acquired rights to specific technologies, to start-ups based on their own technology developed in house. In addition, major renewable energy independent power producers such as Acciona, and utilities such as Iberdrola and Florida Power & Light (FLP) are making plays through various mechanisms for a role in the market.

The supply chain is not limited by raw materials, because the majority of required materials are glass, steel/aluminum, and concrete. At present, evacuated tubes for trough plants can be produced at a sufficient rate to service several hundred MW/yr. However, expanded capacity can be introduced fairly readily through new factories with an 18-month lead time.

Important!

The amount of delivered electricity of a solar thermal power plant strongly depends whether or not the plant has a thermal storage and/or a fossil – generally gas – back-up. The solar fraction of electricity production in southern Spain and the projects in California and Nevada are expected to be between 2000 and 2100 KWh annually per kW installed capacity.

References

[1] Spanish Royal Decree 1/12, published on 28 January 2012 http://www.boe.es/boe/dias/2012/01/28/pdfs/BOE-A-2012-1310.pdf

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Technical Annex:

Trough Systems
The sun's energy is concentrated by parabolically curved, trough-shaped reflectors onto a receiver pipe running along the focal plane of the curved surface. This energy heats oil or another medium flowing through the pipe and the heat energy is then used to generate electricity in a conventional steam generator.

Power Tower Systems
The sun's energy is concentrated by a field of hundreds or even thousands of mirrors called **heliostats** onto a receiver on top of a tower. This energy heats molten salt flowing through the receiver and the salt's heat energy is then used to generate electricity in a conventional steam generator. The molten salt retains heat efficiently, so it can be stored for hours or even days before being used to generate electricity.

Dish/Engine Systems
A dish/engine system is a stand-alone unit composed primarily of a collector, a receiver and an engine. The sun's energy is collected and concentrated by a dish-shaped surface onto a receiver that absorbs the energy and transfers it to the engine's working fluid. The engine converts the heat to mechanical power in a manner similar to conventional engines—that is, by compressing the working fluid when it is cold, heating the compressed working fluid, and then expanding it through a turbine or with a piston to produce work. The mechanical power is converted to electrical power by an electric generator or alternator.

SNAPSHOT ON EUROPEAN SOLAR HEAT 2012

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Introduction

To have an impression of the status of the solar thermal market in Europe for the year 2011, information has been gathered from different sources. The available data reflects the capacity of installed installations and not directly the energy produced or consumed from solar thermal systems. The available data over the past years give a clear trend that can be linked to the 2020 targets set by the Member States.
Annual data is available from National Energy Agencies, solar thermal industry and collected by several organizations, like IEA, ECN and EurObservER.

This snapshot not only gives the 2011 status but intends to give also the market developing trend in the context of the 2020 targets.

As defined in Article 4 of the European Renewable Energy Directive (2009/28/EC) each European Member State has provided a National Renewable Energy Action Plan (NREAP) to the European Commission, detailing projections for renewable energy development up to the year 2020. *The National Renewable Energy Action Plans (NREAPs) are documents in which European Member States explain how they intend to reach their renewable energy targets for the year 2020 and the paths towards them.*

A lot is expected in the coming 8 years from Italy, France, Spain and Poland to reach the 2020 targets to which solar heat might contribute importantly.

Solar thermal

After the impressive growth developments for the year 2008 the solar thermal market in Europe decreased during the following 3 years (2009-2011) as reported by the European Solar Thermal Industry Federation (ESTIF[13] www.estif.org). These figures indicate that solar thermal is suffering from the present economic situation in Europe.

The total market for glazed collectors in the 27 EU Member States and Switzerland increased with 2.6 GWth of new capacity (4,27 million m^2 of collector area). The total capacity in operation at the end of 2011 reached 26.3 GWth (31.6 million m^2 of collector area). The various national markets developed quite differently from one another. The German market has continued to grow while the demand for solar thermal technology increased strongly in smaller markets also, such as Poland and Slovakia. Mediterranean countries as Italy, Spain and Portugal show a notable decrease of growth.

[13] Copyright for figures and tables 2012 © European Solar Thermal Industry Federation (ESTIF) Rue d'Arlon 63-67 - B-1040 Bruxelles.

EU projects have been supporting the development of reliable databases for solar thermal collectors [8]. Usually information is available in m^2 and kWth and energy produced by type of collector (glazed, unglazed & vacuum) from the Member States. The International Energy Agency's Solar Heating & Cooling Programme, together with ESTIF and other major solar thermal trade associations have decided to publish statistics in kWth (kilowatt thermal) and have agreed to use a factor of 0.7 kW_{th}/m^2 to convert square meters of collector area into kWth.

Market development

Concerning solar thermal systems the market in 2011 was flat. In some countries solar thermal technology has become an obligation for construction of new buildings however the construction industry has been reduced dramatically. Solar thermal systems in the built environment are used for:

- Domestic Hot Water systems (DHW), being the major application.
- Space Heating, mainly in Northern Europe
- Space Cooling in the Mediterranean area although at marginal level

The applied solar thermal technology can be distinguished in:

- Flat glazed thermo-siphon systems of about 2-3 m^2 can be found mostly in Southern Europe.
- Flat glazed forced circulation systems of about 2-6 m^2 is installed in Mid- and Northern Europe.
- Evacuated Tube Collectors which have about 15% higher efficiency in south Europe and about 30% in northern Europe than the flat plate collector.
- Unglazed collectors.

Evacuated Tube Collectors take about 11% of the total collector sales in 2011 and keeps this share with the flat plate collector market over the past 5 years. By far, most of the systems are used for Domestic Hot Water (90%). Other applications are space heating (in almost all cases these are combined systems) and pool water heating (mostly by unglazed collectors). Table 1 gives figures for the market development for flat plate (glazed) and vacuum collectors.

Table 1. Market development for glazed collectors for the most recent years.

GW	2006	2007	2008	2009	2010	2011
Total installed capacity	12.7	14.8	18.2	21.1	23.7	26.3
annual growth		2.08	3.34	2.97	2.6	2.56

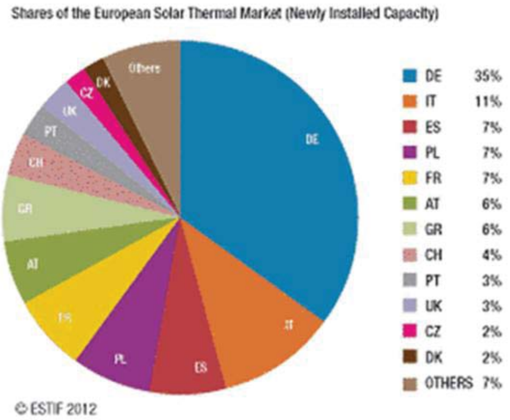

Figure 1. Market share in 2011

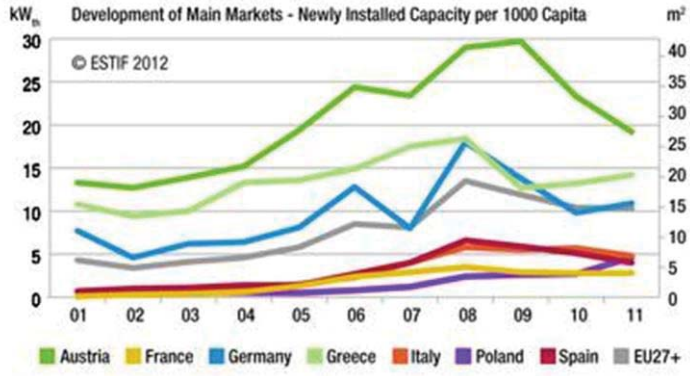

Figure 2. EU Market development

Over the last 5 years the installed solar thermal collector capacity has more or less doubled. However with an average annual growth of 2.7 GW the 2020 target will be missed. The market development might be further hampered by the present economic crisis.

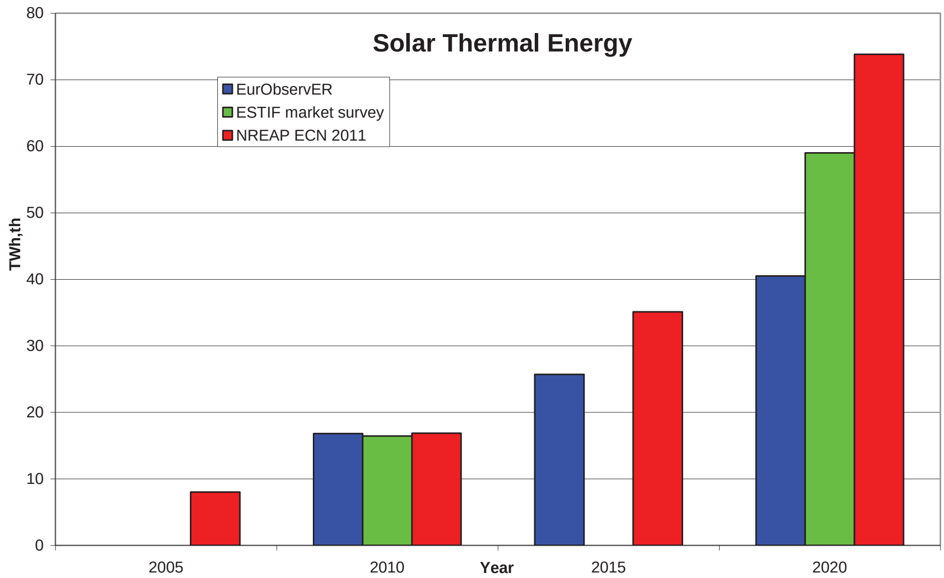

Figure 3. Expected Market development according to NREAP and other projections

In 2011, the installed solar thermal capacity of the top five countries accounted for about 78% of the total – (Germany, Austria, Spain, Italy, Greece). From the big EU countries, Poland is seen amongst the top solar thermal markets whereas despite their strong growth in previous years, the market in Spain and Italy has slowed down dramatically.

Further information

Heat dominates energy end use. Empirical data from final energy consumption shows that heat takes about half of the total consumption.

Table 2. Final energy consumption. Data Source: Elaborated data from Eurostat

	Final energy consumption share [%]
Electricity	20
Heat	48
Fuel for transport	32

Despite its relevant share in the total heat demand, the domestic hot water consumption remains an unknown factor, as no recent and reliable survey regarding this consumption exists. A detailed assessment of this parameter at national and European level would contribute to a better understanding of the heat market.

Solar thermal provides in general low temperature heat and in addition could assist to cooling [9].

The EC-JRC has published recently a report on heating and cooling techniques in SETIS [10]. As heat accounts for nearly 50% of Europe's overall energy demand, major investments are needed in renewable heating and cooling technologies to meet the 20-20-20 targets, to secure energy supply in Europe and to significantly reduce CO_2 emissions. However the economic crisis is hampering a sound development of the solar thermal market.

Solar yield for solar thermal collectors.

For the assessment of renewable energy from solar thermal collectors, the solar yield is an important factor. A proper way to valuate this factor would be to take the solar irradiation for the optimal inclination. For glazed solar collectors this will be the inclination during the coldest month, usually January. In figure 4 an impression is given for Europe how much thermal energy would be produced by 1 m^2 of solar collectors.

A further remark has to be made concerning the optimal inclination because of its definition as the angle that produces the most energy over the whole year. However during the winter months the low level of solar radiation at this inclination is not sufficient to fulfil the request for hot water, and therefore the angle of the solar collectors might be more inclined for more efficiency in the winter than in the summer months.

This radiation map indicates also that for big countries, such as Italy, one solar yield can not be applied but at least three. However to estimate the contribution to the renewable energy target by solar thermal collectors the amount of m^2 should be available per area or region.

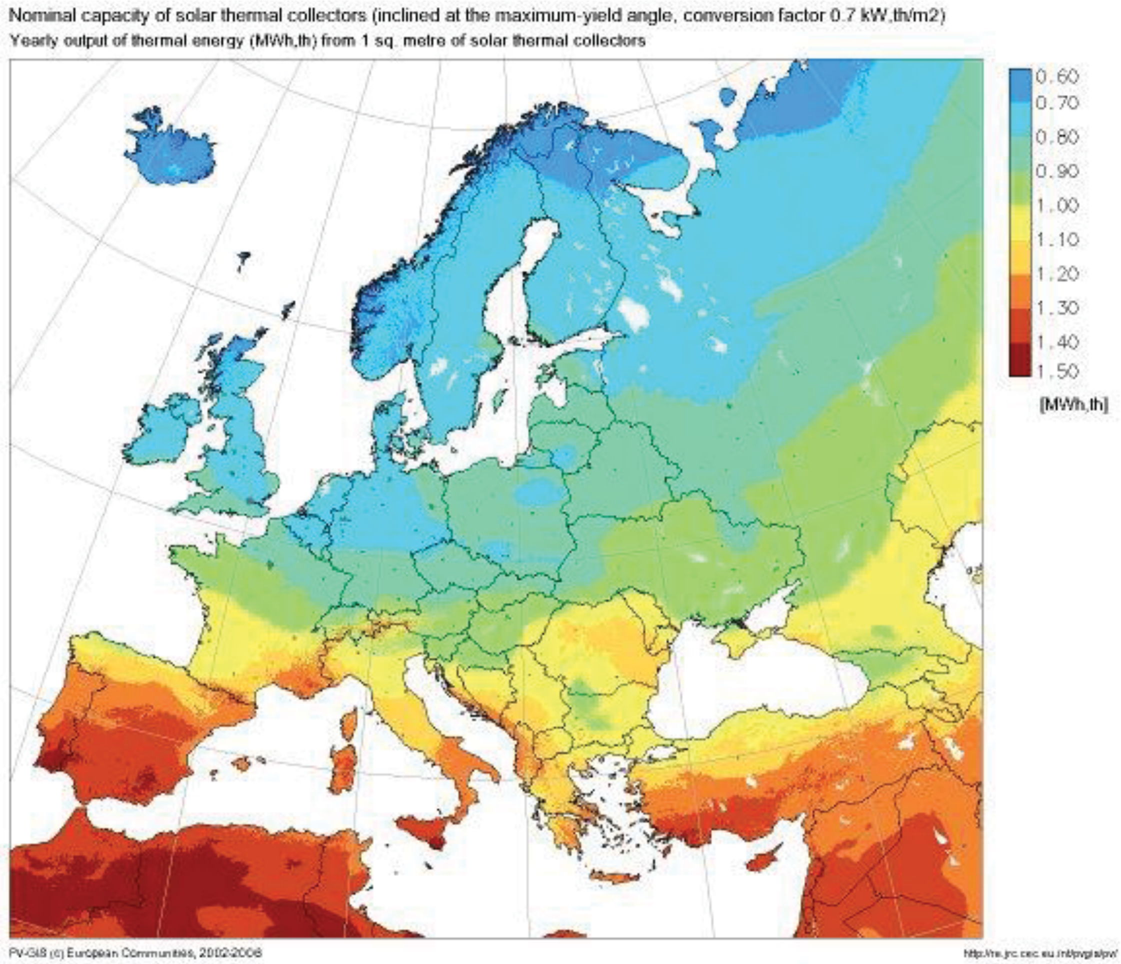

Figure 4: Yearly global irradiation at optimal inclination for solar energy applications. See also [5]

Note that roughly a factor 2 can be applied when Northern Europe is compared with the Mediterranean area. In practice this means that a house-owner in Scandinavia will need twice more m^2 of solar collectors than in Southern Europe to achieve the same capacity.

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PHOTOVOLTAIC SNAPSHOT 2012

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Production data for the global cell production[14] in 2011 vary between 30 GW and 37 GW and estimates for 2012 are in the 35 to 40 GW range. The significant uncertainty in this data is due to the highly competitive market environment, as well as the fact that some companies report shipment figures, while others report sales and again others report production figures. 2011 was characterised by a sluggish first half year and a boom in the fourth quarter of 2011. During the first three quarters of 2012 the market outlook for the current year improved considerably and especially in Asia a strong 4th quarter is predicted, mainly due to increased demand in China and Japan.

The data presented, collected from stock market reports of listed companies, market reports and colleagues, were compared to various data sources and thus led to an estimate of 35 GW (Fig. 1), representing an increase of 37% compared to 2010 and another moderate increase is expected for 2012.

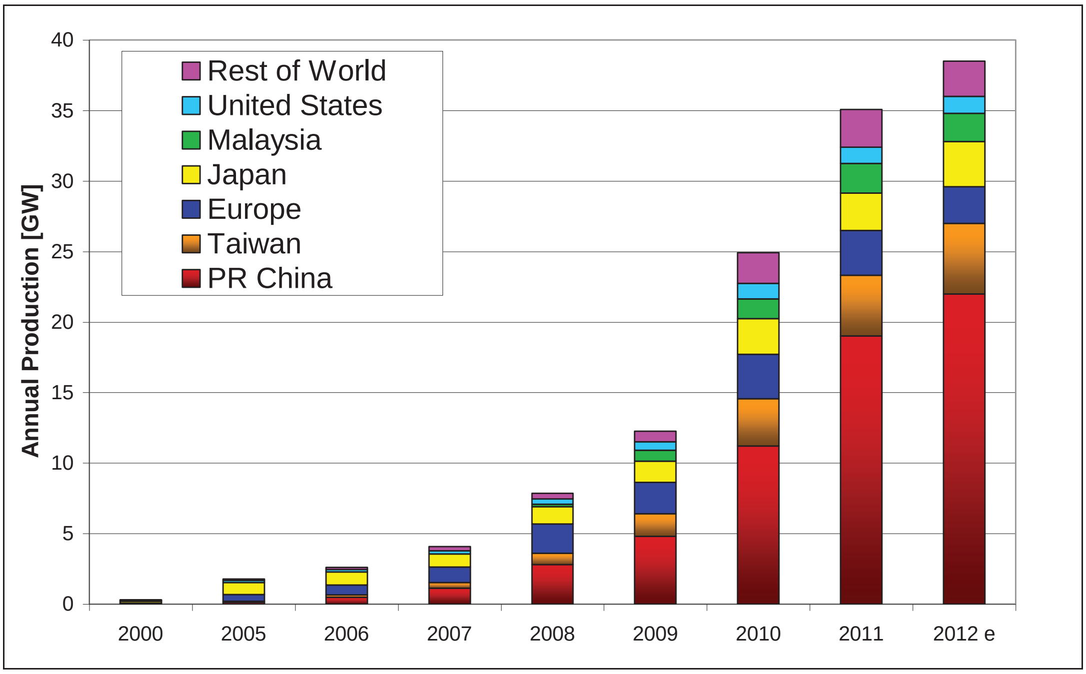

Figure 1: World PV Cell/Module Production from 2000 to 2012
(data source: Photon Magazine [1], PV Activities in Japan [2], PV News [3] and own analysis)

Since 2000, total PV production increased almost by two orders of magnitude, with annual growth rates between 40% and 90%. The most rapid growth in annual production over the last five years

[14] **Solar cell production capacities** mean:
- In the case of wafer silicon based solar cells, only the cells
- In the case of thin-films, the complete integrated module
- Only those companies which actually produce the active circuit (solar cell) are counted
- Companies which purchase these circuits and make cells are not counted.

could be observed in Asia, where China and Taiwan together now account for more than 65% of world-wide production.

The change of the market from a supply restricted – to a demand-driven market and the resulting overcapacity for solar modules has resulted in a dramatic price reduction of PV systems of more than 50% over the last four years. In the second quarter of 2012, the average system price for systems smaller 100 kWp was in the range of 1.78 €/Wp (2.3 $/Wp) in Germany and 2.30 €/Wp (3.0 $/Wp) in Italy, but between 6 and 6.5 $/Wp (4.6 – 5.0 €/Wp) in California and Japan [4, 5]. Bloomberg New Energy Finance expects a further price reduction there in-line with the decrease of incentives. Engineering, Procurement and Construction (EPC) quotes for large systems are already much lower and turnkey system prices as low as 1 €/Wp (1.3 $/Wp) have been reported for projects to be finished in 2013 [4].

Market predictions for the 2012 PV market vary between 20.2 GW and 40.2 GW [6, 7] with a consensus value in the 30 GW range. For 2013 analysts expect a flat market or even shrinking market due the expected market size reductions in Germany and Italy. Despite these forecasts, massive capacity increases are still ongoing or announced and if all of them are realised, the world-wide production capacity for solar cells would exceed 80 GW at the end of 2012. This indicates that even with the optimistic market growth expectations, the planned capacity increases are way above the market growth. The consequence would be either low utilisation rates or the build up of high inventories resulting in a continued price pressure in an oversupplied market. Such a development will accelerate the consolidation of the photovoltaics industry and spur more mergers and acquisitions.

Despite the fact that a significant number of companies filed for insolvency, scaled back or even cancelled their expansion projects, the number of new entrants into the field, notably large semiconductor or energy related companies overcompensated this. The announced production capacities – based on a survey of more than 300 companies worldwide – increased again in 2012. At least on paper the expected production capacities are increasing. Only published announcements of the respective companies and no third source info were used. The cut-off date of the used info was September 2012.

It is important to note, that production capacities are often announced, taking into account different operation models such as number of shifts, operating hours per year, etc. In addition the announcements of the increase in production capacity do not always specify when the capacity will be fully ramped up and operational. This method has of course the setback that a) not all companies announce their capacity increases in advance and b) that in times of financial tightening, the announcements of the scale back of expansion plans are often delayed in order not to upset financial markets. Therefore, the capacity figures just give a trend, but do not represent final numbers.

If all these ambitious plans can be realised by 2015, China will have about 61.1% of the world-wide production capacity of 119 GW, followed by Taiwan (14.3%), Europe and Japan (5.5%) (Fig. 2).

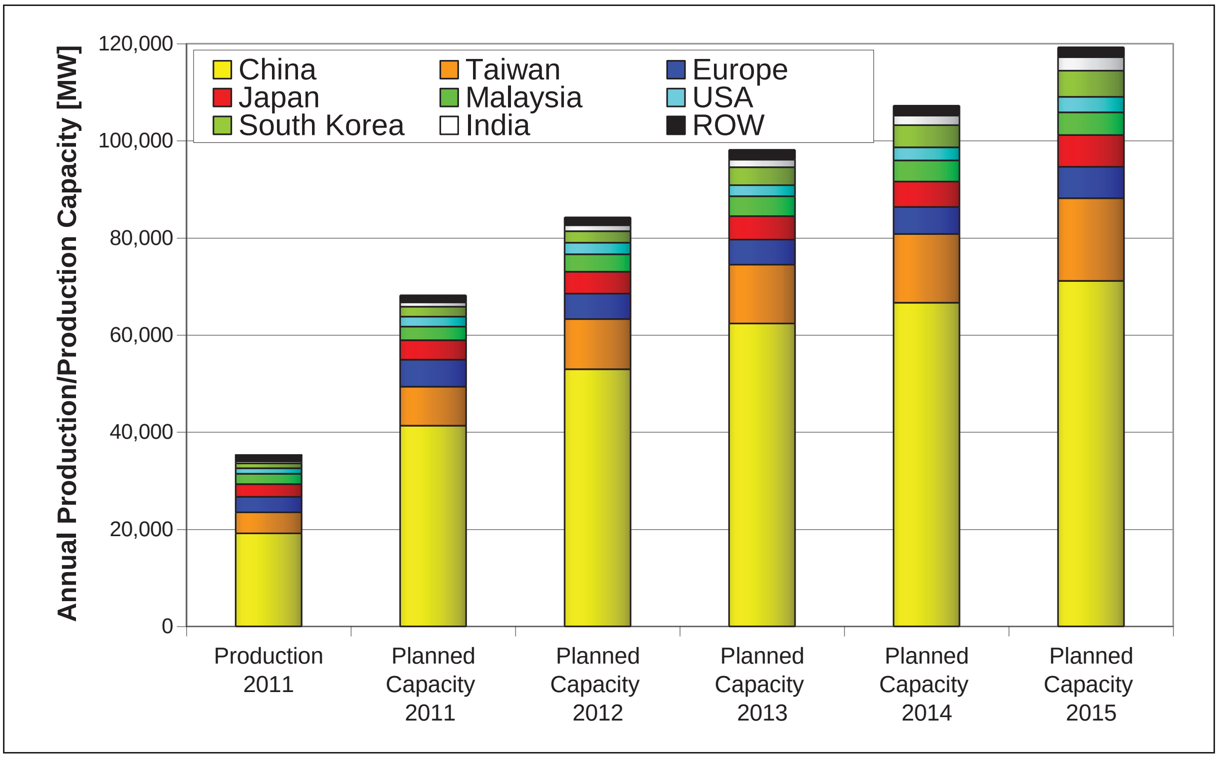

Figure 2: World-wide PV Production and planned production capacity increases

All these ambitious plans to increase production capacities at such a rapid pace depend on the expectations that markets will grow accordingly. This, however, is the biggest uncertainty as the market estimates for 2012 and 2013 vary between 20 GW and 40 GW with a consensus value in the 30 GW range respectively. In addition, most markets are still dependent on public support in the form of feed-in tariffs, investment subsidies or tax-breaks.

After the world-wide photovoltaic market more than doubled in 2010, the market grew again by almost 30% in 2011, despite difficult economic conditions. The 2010 market volume of 20.9 GW includes those systems in Italy, which were reported under the second "*conto energia*" and probably already installed, but not yet connected. The continuation of the strong market in Italy and a year-end rush in Germany, where in the 4th quarter about 4GW (3 GW in December alone) in conjunction with rapidly growing markets outside Europe in China and the USA resulted in a new installed capacity of almost 27 GW and for 2012, a modest increase to about 30 GW is expected (Fig. 3). This represents mostly the grid connected photovoltaic market. To what extent the off-grid and consumer product markets are included is not clear, but it is believed that a substantial part of these markets are not accounted for as it is very difficult to track them. A conservative estimate is that they account for approx. 400 to 800 MW (approx. 1-200 MW off-grid rural, approx. 1-200 MW communication/signals, approx. 100 MW off-grid commercial and approx. 1-200 MW consumer products).

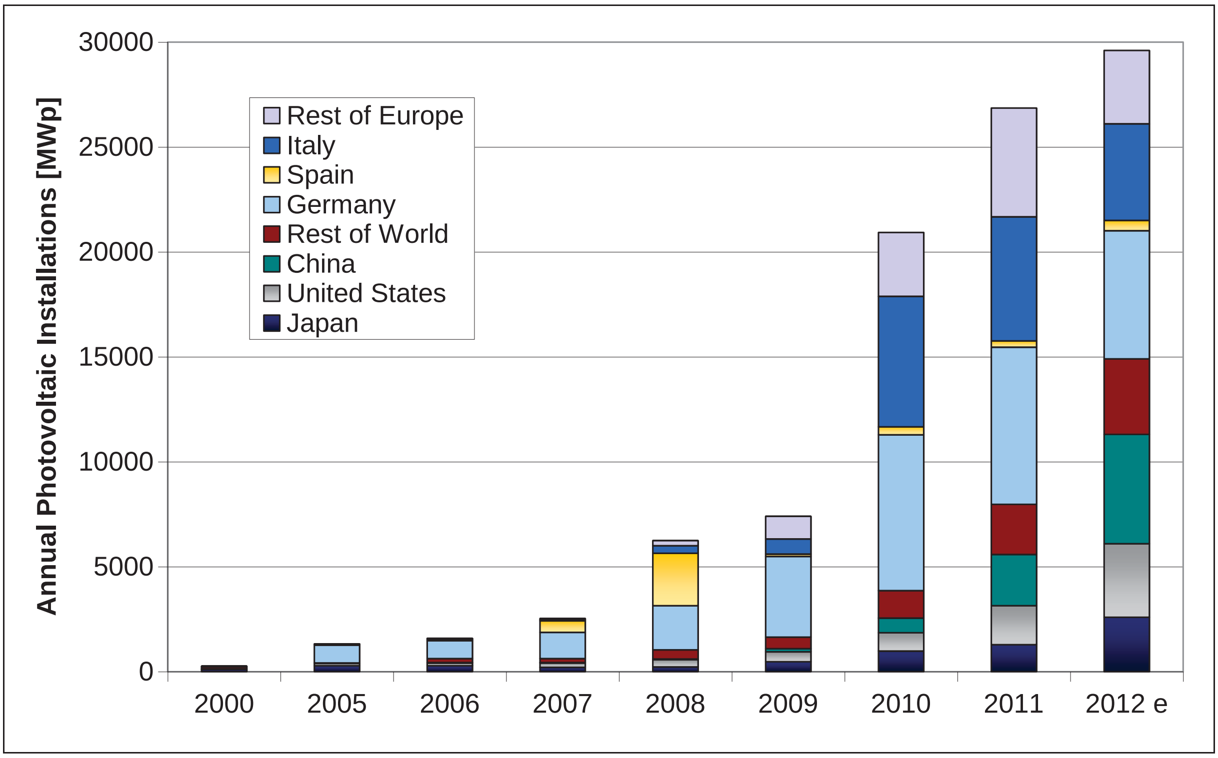

Figure 3: Annual photovoltaic installations from 2000 to 2012 (data source: [6,7,8] and own analysis)

With a cumulative installed capacity of over 66 GW, the European Union is leading in PV installations with 2/3 of the total world wide almost 100 GW of solar photovoltaic electricity generation capacity at the end of 2012.

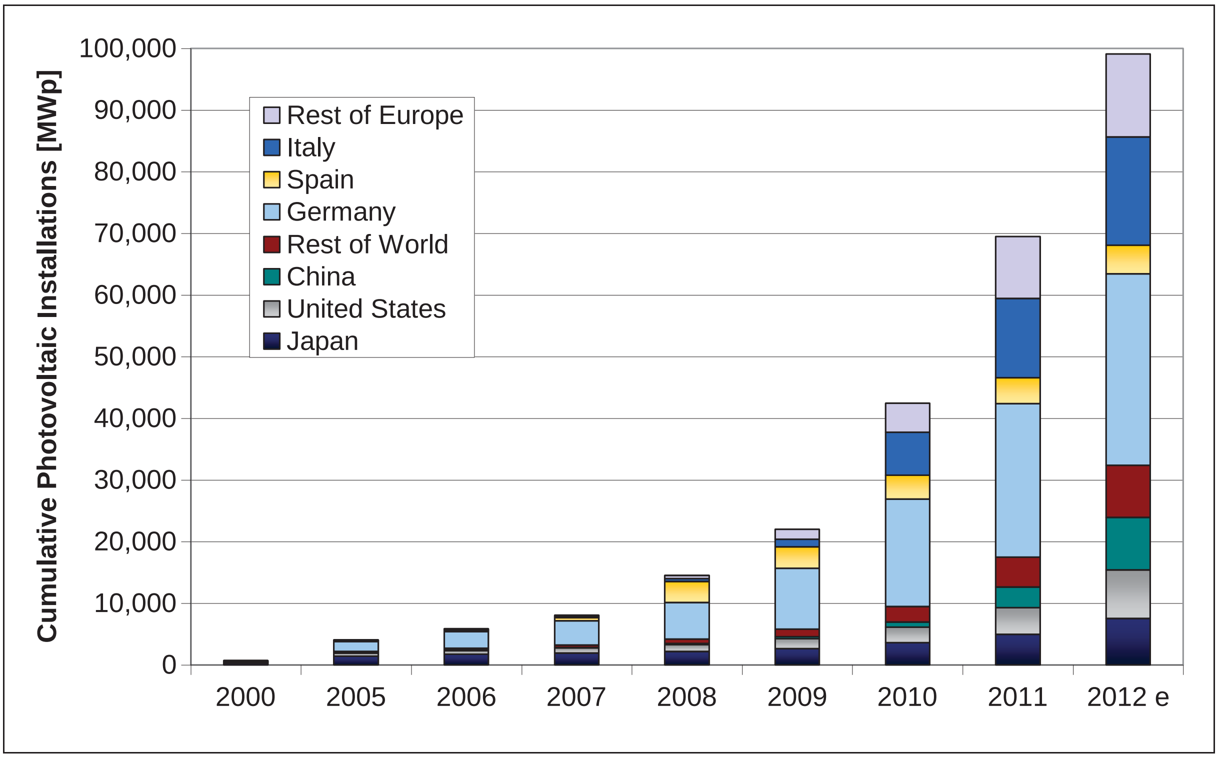

Figure 4: Cumulative Photovoltaic Installations from 2000 to 2012 (data source: [6, 7, 8] and own analysis)

The **Asia & Pacific Region** shows an increasing trend in photovoltaic electricity system installations. There are a number of reasons for this development, ranging from declining system prices, heightened awareness, favourable policies and the sustained use of solar power for rural electrification projects. Countries such as Australia, China, India, Indonesia, Japan, Malaysia, South Korea, Taiwan, Thailand, The Philippines and Vietnam show a very positive upward trend, thanks to increasing governmental commitment towards the promotion of solar energy and the creation of sustainable cities.

The introduction or expansion of feed-in-tariffs is expected to be an additional big stimulant for on-grid solar PV system installations for both distributed and centralised solar power plants in countries such as Australia, Japan, Malaysia, Thailand, Taiwan and South Korea.

In 2011 about 5.3 GW of new PV electricity generation systems were installed in the region. This was more than double the installation in 2010. The largest market was China with 2.4 GW followed by Japan with 1.3 GW MW and Australia with 840 MW. For 2012 a market increase to about 10 GW is expected, driven by the major market growth in China (~ 5 to 6 GW), India (1 GW), Japan (> 2GW), Malaysia and Thailand. Market expectations for the region range between 10 to 14 GW in 2013.

The Asian Development Bank (ADB) launched an Asian Solar Energy Initiative (ASEI) in 2010, which should lead to the installation of 3 GW of solar power by 2012 [9]. In their report, ADB states: *Overall, ASEI aims to create a virtuous cycle of solar energy investments in the region, toward achieving grid parity, so that ADB developing member countries optimally benefit from this clean, inexhaustible energy resource.*

European Union: Market conditions for photovoltaics differ substantially from country to country. This is due to different energy policies and public support programmes for renewable energies and especially photovoltaics, as well as the varying grades of liberalisation of domestic electricity markets. After a tenfold increase of solar photovoltaic electricity generation capacity between 2001 and 2008, the newly installed capacity increased more than sixfold in the last four years to exceed 66 GW cumulative installed capacity at the end of 2012.

The legal framework for the overall increase of renewable energy sources was set with the Directive 2009/28/EC, and in their National Renewable Energy Action Plans (NREAPs), 26 Member States have set specific photovoltaic solar energy targets, adding up to 84.5 GW in 2020. However, since the submission of the NREAPs in 2010 a number of positive signs have emerged for PV. In Italy, the cumulative installed capacity by October 2012 has already reached 16 GW or double the NREAP target. In August 2011 Greece announced the "Helios" project, which aims to install up to 10 GW of PV electricity systems on public land by 2020.These developments indicate that the targets set in the NREAPs should be seen as the guaranteed minimum and not the overall goal.

In 2011 Italy overtook Germany as the biggest market with an expected new connected capacity of 9.2 GW versus 7.5 GW respectively. For 2012 about 4.5 GW for Italy and 6 to 7 GW for Germany are estimated. The market growth in these two countries is directly correlated to the introduction of the Renewable Energy Sources Act or *"Erneuerbare Energien Gesetz"* (EEG) in Germany in 2000 and the *Conto Energia* in Italy in 2005.

North America: In 2011, Canada almost doubled its cumulative installed PV capacity to about 560 MW, with 270 MW new installed systems. For 2012 a further increase of the market to 500 to 600 MW is estimated. This development is driven by the introduction of a feed-in tariff in the Province of Ontario in 2009.

With over 1.8 GW of new installed PV capacity, the USA reached a cumulative PV capacity of almost 4.4 GW at the end of 2011. Utility PV installations again more than tripled, compared to 2010 and reached 754 MW in 2011. The top ten States - California, New Jersey, Arizona, New Mexico, Colorado, Pennsylvania, New York, North Carolina, Texas and Nevada, accounted for more than 87% of the US PV market [10]. For 2012 an increase of the US market to 3.5 GW is estimated.

PV projects with Power Purchase Agreements (PPAs), with a total capacity of 9 GW, are already under contract and to be completed by 2016. Over 3 GW of these projects are already financed and under construction [10]. If one adds the over 30 GW of projects in an earlier planning stage, which are actively seeking permits, interconnection agreements, PPAs and finance, the pipeline stands at 39 GW.

Many State and Federal policies and programmes exist and one of the most comprehensive databases about the different support schemes in the US is maintained by the Solar Centre of the State University of North Carolina. The Database of State Incentives for Renewable Energy (DSIRE) is a comprehensive source of information on State, local, utility, and selected Federal incentives that promote renewable energy. All the different support schemes are described therein and it is highly recommended to visit the DSIRE web-site http://www.dsireusa.org/ and the corresponding interactive tables and maps for details.

The 2013 market expectations for Canada and the USA together vary between 4.5 and 5.5 GW.

The Photovoltaic Industry has changed dramatically over the last few years. China has become the major manufacturing place followed by Taiwan and Japan.

Looking at Photovoltaics it is important to remember, that the PV industry is more than just cell and module manufacturing and to grasp the whole picture one has to look at the whole PV value chain. Besides the information in this paper about the manufacturing of solar cells, the whole upstream industry (e.g. materials, polysilicon production, equipment manufacturing), as well as the downstream industry (e.g. inverters, BOS components, system development, installations) has to be looked at as well.

In the following analysis about "European Value"of a PV system, a PV system price of 2,300 €/kWp – the situation in Italy mid 2012 – taken from Bloomberg New Energy Finance [11] was used. The cost breakdown of the 2.3 €/Wp system costs per Wp are as follows (Fig. 5): € 0.99 module, € 0.2 inverter, € 0.51 balance of system (BoS), € 0.42 engineering, procurement & construction, € 0.18 (others, e.g. fees, insurance, etc.). For the module costs, it was assumed that even if the modules are imported, about 25% of the module cost can be attributed to the European made manufacturing equipment, materials production like polysilicon or ingot/wafer production, conductive pastes etc. For inverters and the BoS a European share of 90% was estimated. With these assumptions, the European value in the PV system costs was calculated at 65% or 1.50 €/Wp.

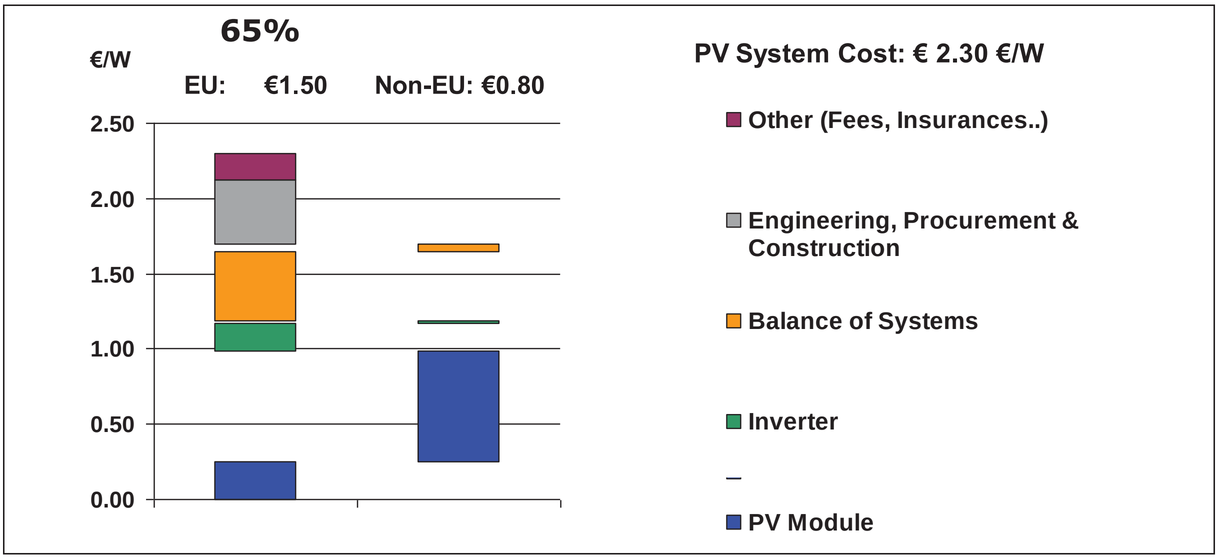

Figure 5: Breakdown of PV system costs

This calculation is in agreement with calculations presented by Vanbuggenhout et al at the 27th European Photovoltaic Energy Conference and Exhibition, 24 to 28 September 2012, Frankfurt, Germany [12]. The estimated market volume is about € 42.5 billion and does not include "Value Chain Services" (incl. transportation, storage, distribution) nor operation and maintenance (O&M) services, which could add another € 9 to 10 billion with more than 80% European share in it [12].

According to investment analysts and industry prognoses, solar energy will continue to grow at high rates in the coming years. The different Photovoltaic Industry Associations, as well as Greenpeace, the European Renewable Energy Council (EREC) and the International Energy Agency, have developed new scenarios for the future growth of PV. Table 1 shows the different scenarios of the Greenpeace/EREC study, as well as the different 2011 IEA *World Energy Outlook scenarios* and the IEA PV Technology Roadmap. It is interesting to note that the 2015 capacity values of only two scenarios the Greenpeace [revolution] and IEA New Policy Scenarios are net reached at the end of 2012. With forecasted new installation of between 79 and 100 GW in 2013 to 2015 even the Greenpeace revolution scenario is no longer fictional thinking [4, 6].

Table 1: Evolution of the cumulative solar electrical capacities until 2050 [13, 14, 15]

Year	2012 [GW]	2015 [GW]	2020 [GW]	2030 [GW]	2035 [GW]
Actual Installations	**100**				
Greenpeace* (reference scenario)		88	124	234	290
Greenpeace* ([r]evolution scenario)		234	674	1,764	2,420
IEA Current Policy Scenario**		60	161	268	314
IEA New Policy Scenario		112	184	385	499
IEA 450ppm Scenario**		70	220	625	901
IEA PV Technology Roadmap***		76	210	872	1,330

* 2035 values are extrapolated, as only 2030 and 2040 values are given

** 2015 values are extrapolated, as only 2009 and 2020 values are given

*** 2015 and 2035 values are extrapolated, as only 2010, 2020, 2030 and 2040 values are given

With worldwide 100 GW cumulative installed photovoltaic electricity generation capacity installed by the end of 2012, photovoltaics still is a small contributor to the electricity supply, but its importance for our future energy mix is finally acknowledged.

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2012 SNAPSHOT ON EUROPEAN WIND ENERGY

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The state of play

Between 40.5 GW [1] and 41.7 GW [2], depending on the sources, of new wind turbine capacity was installed in 2011, bringing the worldwide total installed wind capacity to 240 GW (Figure 1). This capacity can produce about 528 TWh[15] of electricity in an average year, or approximately 2.7 % of global electricity demand.

With almost 18 GW of new installations, China had a 42 % market share of new installations, followed by the US with 6.8 MW (16 %) and India with 3 MW (7.5 %). European Union Member States added 9 618 MW (24 %), with Germany (2 086 MW), the UK (1 293 MW), and Spain (1 050 MW) as main contributors. Another four EU countries added 500 MW or more: Italy (950 MW) France (850 MW), Sweden (763 MW), and Romania (520 MW). Other European countries and Turkey added 665 MW. Of the rest of the world, Canada with 1 267 MW (3 %) and Brazil (583 MW) also surpassed the 500-MW mark.

The total value of new generation capacity installed in 2011 is estimated at €50-52 billion, giving an average turbine price of around €1 240/kW.

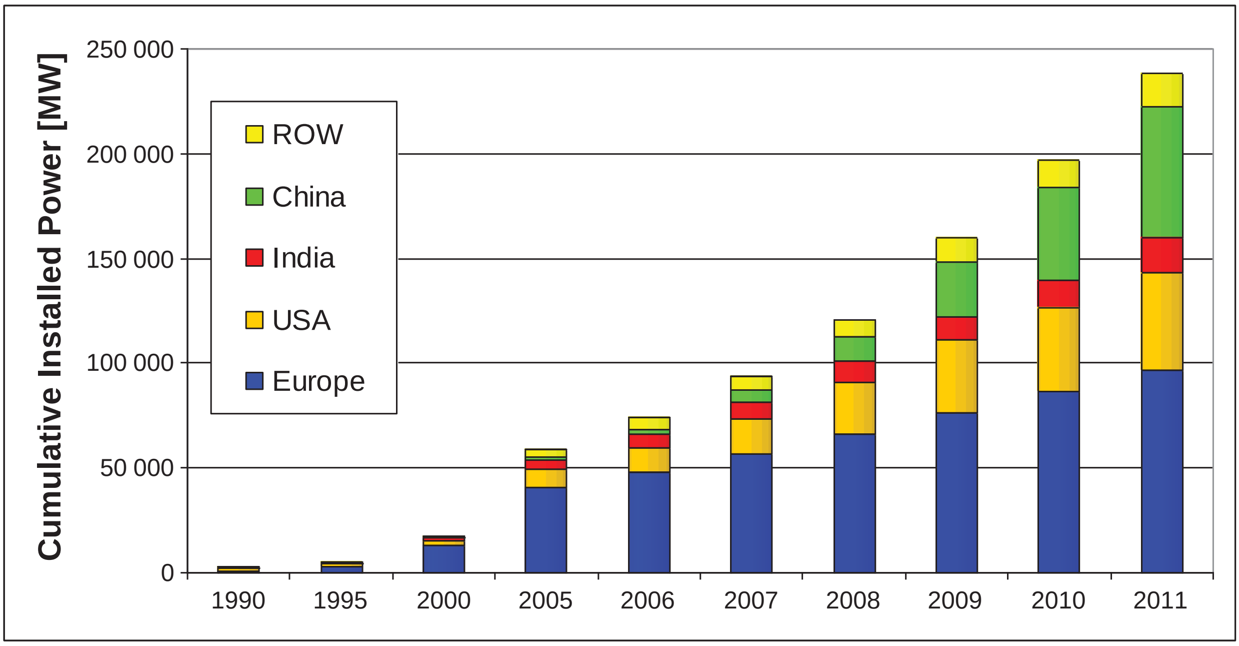

Figure 1: Cumulative worldwide installed wind power capacity from 1990 to 2011 Data Source: BTM, GWEC, WWEA, EWEA [1, 2, 3, 4]

[15] Assuming an average capacity factor of 2200 hours or 25 %.

China increased its lead over the United States in terms of installed capacity (62.4 vs. 47.1 GW, see Figure 1), although an estimated 15 GW of non-grid-connected wind turbines in China puts both countries on a par in terms of operational capacity. They were followed by Germany (29.1 GW), Spain (21.7 GW) and India (16.1 GW).

The shift in market weight towards Asia is reflected in the variations in installed capacity. After Europe led the world market in 2004 with 75 % of new installations, in five years Europe, North America and Asia reached an almost even distribution of annual market shares. By 2011, Asia dominated installations with almost 52 %, whereas the North American share sharply declined to 20 %, leaving Europe with 25 %.

In terms of percentage annual growth, in 2011, the European Union's wind capacity grew by 11.4 %, well below the global average of 20.5 %. The total EU capacity of 94 GW is equal to 10 % of the total European electricity generation capacity [4] and is capable of producing approximately 178 TWh[16] of electricity or roughly 6 % of European electricity consumption.

The German market still represented 22 % of the EU market in 2011 (with year-on-year growth of 40 %), while the other traditional leader, the Spanish market, fell to third position with 11 % (y-o-y reduction of 30 %), after the United Kingdom's 13.5 % (y-o-y +30 %). Italy with 10 % (y-o-y 0 %) and France with 8.5 % (y-o-y -24 %), complete the group of five EU countries with more than 5 GW installed capacity at the end of 2011.

Figures for offshore wind installations vary widely depending on the source, due to the different methodologies used. Based on the date that turbines start producing electricity, 2011 saw a disappointing performance with a 30 % reduction in installed capacity from 1 242 to 876 MW. The latter figure includes the 382 MW installed in 2011 out of the 504 MW total of the UK's Greater Gabbard wind farm which, if shifted to 2012, leaves the 2011 figure at an even more disappointing total of 504 MW worldwide.

Table 1: Annual installations offshore, in MW. 2012 data are for first quarter only.

Country	**< 2001**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Total**
Belgium									30		165			195
China										69	272	114		455
Denmark	10	40	160	210						230	207			858
Finland	1									30	2			33
Germany									5	60	40	88		193
Ireland					25									25
Netherlands	19						108		120			5		252
Norway										2				2
South Korea												2		2
Sweden	3	11	10					110		30				164
UK	4			60	60	90	90	100		382	556	667	234	2242
Total	37	51	170	270	86	90	198	210	155	803	1242	876	234	4423

[16] Assuming a capacity factor of 1890 hours, equal to the European average for the years 2000-2009.
Source: JRC based on Eurostat and industry data.

Denmark's Vestas continued to defend its top manufacturing position, followed by Goldwind of China and GE Wind of the US (**Error! Reference source not found.**). The high contribution of the Chinese market to global installations (42 %) resulted in Chinese manufacturers accounting for four of the top 10 wind turbine manufacturers (and seven of the top 15) [2], including Sinovel (7), Guodian United Power (8) and Ming Yang (10). However, this world ranking is actually the result of Chinese firms' dominance of their national market (91 % in 2011) [5] and Chinese firms commissioned less than 100 MW outside China in 2011 [6]. This figure is less than 0.6 % of the total 16 000 MW installed by Chinese firms [5, 6]. By contrast, foreign firms installed 1 626 MW in China, a reduction of 19 % over the 2 000 MW installed in 2010.[17]

A significant difference in the 2011 statistics compared with those for previous years is the coincidence among main providers of data, who see a 12.9 % share for the market leader, Vestas, with the next eight manufacturers grouped very closely together, mostly between 7 and 9 % of the global market.

Analysis and projections

Annual market projections are now a little less optimistic than two years ago, with BTM Consult expecting 2014 installations of 52 GW, whereas two years ago that figure was estimated at 71 GW [2, 7]. Factors that influence current projections include an expected reduction of the annual Chinese market to between 15 and 18 GW, and an increase in India and other emerging markets. Asia as well could see a radical change as the Japanese society rejects nuclear power and looks to renewables to fill the gap left by the future reduction of nuclear electricity. Japan, a traditional mid-market with 2 500 MW of total wind installed capacity (168 MW in 2011), just introduced a generous feed-in-tariff of 23100 JPY/MWh (€227/MWh) for 20 years [8] which should boost the Japanese market for years to come.

Over the last few years, European installations have remained at between 9 and 10 GW. Stability is likely in Europe, with offshore wind and new onshore markets (countries) pushing up annual figures to around 10-12 GW per year despite a reduction in installations expected in current leading markets.

In North America, the US market will likely stagnate in the absence of an extension to their main support mechanism, the Production Tax Credit (PTC), beyond the end of 2012, and, in any case, the current standoff in its extension is already strongly discouraging projects for 2013. Canada and Mexico, by contrast, are showing signs of increased growth and very positive projections, in some cases aided by know-how (e.g. developers' know-how) escaping from the stagnating US market.

[17] Note that, given the specificities of the Chinese market –where installed does not necessarily involve 'commissioned' or 'grid-connected', Chinese figures correspond to installed turbines whereas the market outside China is made up of grid-connected turbines.

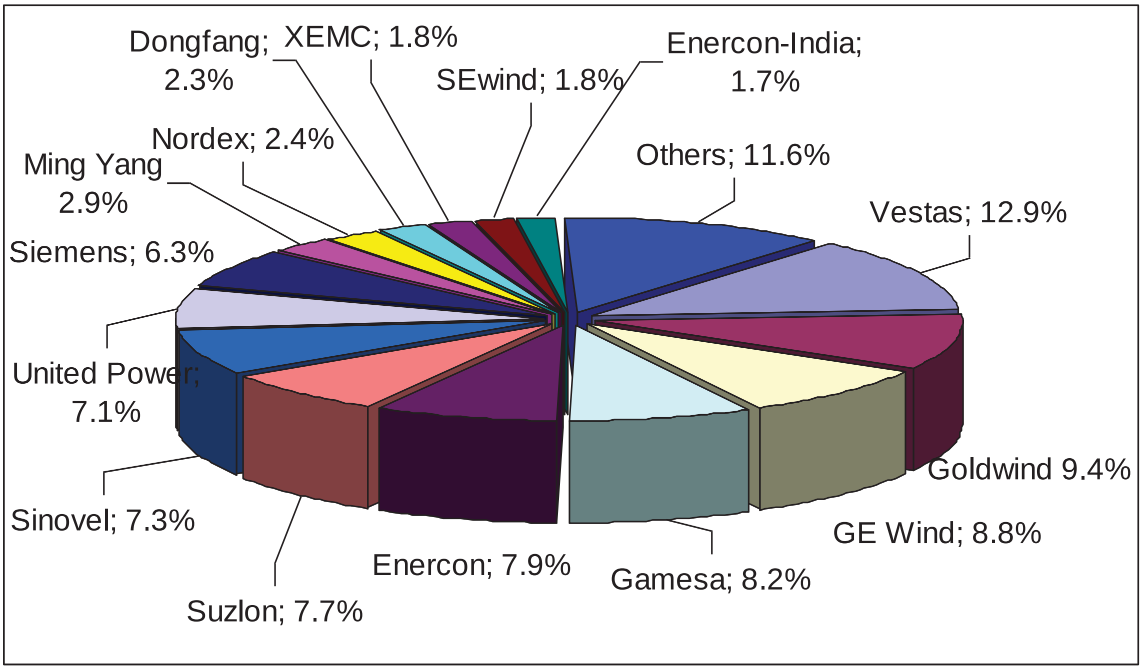

Figure 2: Market shares of manufacturers 2011 (41.7 GW of installations) [2]. Suzlon data includes its subsidiary REpower (Germany)

Wind power is the fastest-growing source of power generation in Brazil. In 2011, 50 % of all newly installed wind power in Central and South-America was in Brazil. At the end of 2011, there were approximately 1.5 GW of installed capacity, another 7 GW in the pipeline by 2016, and the projections for cumulative installed capacity in 2020 are for more than 15 GW.

The two leading African markets per installed capacity, Egypt and Morocco, experienced zero growth in 2011 and remained at 550 and 290 MW respectively. However, perspectives are good as Egypt is planning to increase this capacity to about 2.7 GW by 2016 and 7.2 GW by 2020 and in Morocco in early 2012 three projects were signed, which would more than double this capacity by 2013. In addition, a 850-MW tender was published as part of a push to reach 2 GW of wind power capacity by 2020.

In 2011, South Africa accepted bids for 1.8 GW of wind projects to be realised by 2016, which have to close financing by June 2012. As a result of the first renewable energy project bidding round, projects with 630 MW of wind power have been awarded contracts. The results of the second bidding round in 2012 are not yet known, but could add another 05. to 1 GW of capacity.

Despite the reduction of annual growth rates, world and European 2020 targets are still feasible. These are 230 GW for the EU, of which 40 GW offshore, and 670 GW globally, of which 110 GW offshore [9].

The wind turbine-manufacturing sector currently has production overcapacity, particularly in China, as markets did not grow as fast as production capacities. Players in China, the largest world market, are under additional pressure as its size is expected to decrease because of the new legislation put in place by the Chinese government to improve management of installations and grid connection. Taken together, these factors should result in sector consolidation, along with an increase in Chinese companies' exports that will further result in price pressure for European manufacturers both at home and abroad.

Chinese manufacturers will start seriously grabbing a part of the market outside their home country, starting with the technologies that are more bankable. Nowadays, these are turbines with permanent-magnet generators with full converter, based on European designs (e.g. Goldwind-Vensys, XEMC-Darwind). This trend will be aided by the fact that non-Chinese turbine manufacturers increasingly source from the Chinese supply chain, and thus companies in this supply chain are reaching foreign levels of quality.

For both bankable and not-so-bankable Chinese turbines, entry into Western markets involves (a) becoming developers of wind farms where they use their own machines; (b) through the help of Chinese banks providing the finance for projects. Countries where this is happening include the US, India, Romania, Pakistan and some in South America.

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RES STATUS IN THE NATIONAL RENEWABLE ACTION PLANS

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Directive 2009/28/EC on the promotion of the use of energy from renewable energy sources (RES Directive) not only set the mandatory targets for the European Union's Member States, but also drafted a trajectory how to reach the targets for each of them and requires Member States to adopt a National Renewable Energy Action Plan (NREAP), setting out sectoral targets and measures for achieving these targets.

Each Member State has set its national target for the share of energy coming from renewable sources, consumed in three main sectors: electricity, transport and heating and cooling, providing a yearly target up to 2020. The MS have the obligation to submit the NREAPs to the European Commission every two years up to 2020.

Upon NREAPs the total installed RES capacity in EU 27 in 2020 will be 475.8 GW increasing from 248.8 GW in 2010. The total RES generation potential is expected to reach in 2020 the amount of 2871 TWh (10336.7 PJ) growing from 1613 TWh (5808.2 PJ) in 2010 and 1163 TWh (4188.4) in 2005 having a CAGR of 5.9%. The RES breakdown by source in EU 27 generation potential from the baseline year to the target year in absolute and relative term is presented in the Table 1 and Figure 1.

Table 1. RES breakdown by source in EU27 generation potential from 2005 to 2020 in PJ

	2005*	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Hydropower	1208,	1223,	1226	1233,	1241,	1249,	1255,	1260,	1273,9	1280,7	1293,4	1305,3
Geothermal	38,2	50,3	55,0	60,5	67,5	75,6	82,9	94,6	106,2	120,4	132,6	149,3
Solar total	34,2	136,2	182,	221,6	262,5	301,0	343,9	392,5	443,9	499,9	559,7	627,2
Solar	5,3	74,5	112,	141,7	168,0	192,6	217,5	243,6	270,3	298,4	328,7	361,4
PV	5,3	72,0	102,	124,2	143,8	164,0	183,5	204,2	225,2	247,0	269,5	293,0
CSP	0,0	2,5	9,8	17,5	24,2	29,4	33,9	39,4	45,1	51,4	59,2	68,4
Solar thermal	28,9	61,6	70,3	79,9	94,5	108,4	126,4	148,9	173,6	201,6	231,0	265,8
Marine	1,9	1,8	1,8	2,1	2,4	2,7	3,1	6,4	10,0	13,6	18,2	23,4
Wind total	253,3	597	690,	784,3	890,8	999,7	1107,	1223,	1349,0	1486,7	1613,3	1759
Onshore	240,6	563,2	642,	710,9	777,5	849,1	919,7	979,9	1043,3	1118,3	1180,4	1261,9
Offshore	6,9	31,2	44,2	68,1	106,7	142,8	178,6	230,4	289,4	348,4	409,2	491,5
Heat pump	25,7	168,1	196,	225,9	249,2	274,6	303,5	336,9	372,4	412,9	454,5	508,8
Biomass	2455,	3000,	3127	3251,	3395,	3529,	3676,	3839,	4014,8	4194,4	4414,1	4618,3
RES transport	170,9	630,6	715,	773,7	798,4	847,1	902,3	959,7	1065,3	1136,1	1205,1	1345,6
Total RES	4188,	5808,	6196	6553,	6907,	7279,	7674,	8113,	8635,6	9144,9	9690,9	10336,7

* MT and HU did not reported the RES generation data for 2005

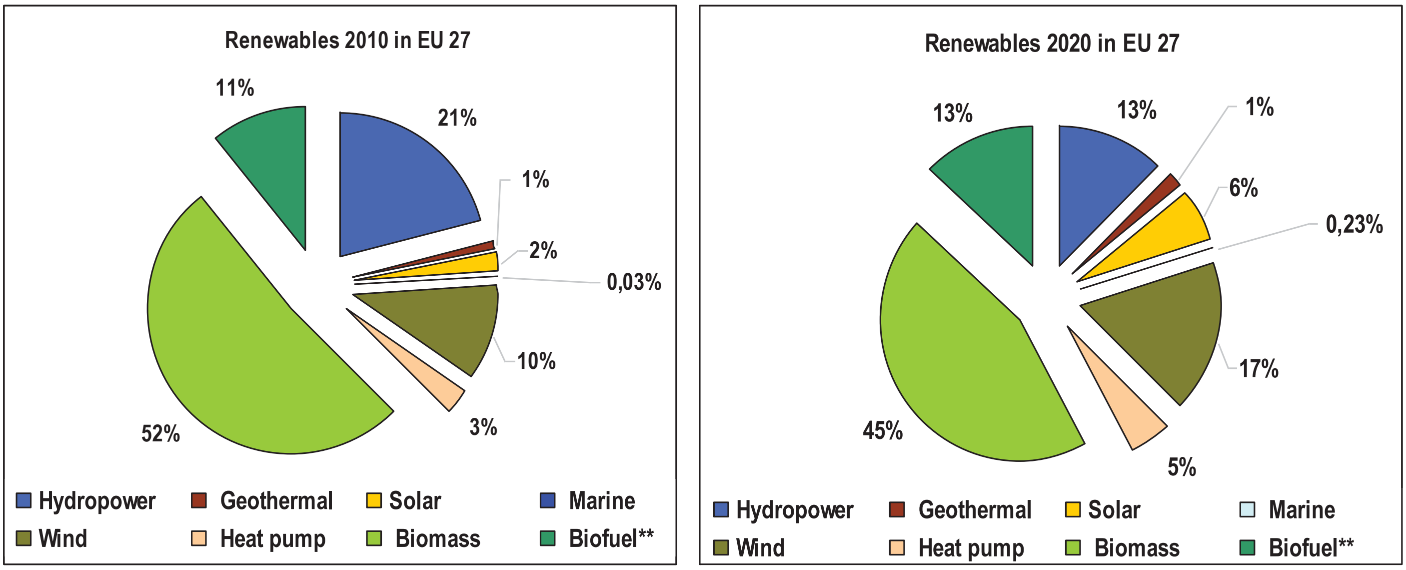


Figure 1. Resource share in RES in the EU27 in 2010 and 2020

The yearly growth rate of energy production from RES in 2010 compared to 2005 was 38.7% and in 2020 is projected to be 6.7% (Table 2).

Table 2. Yearly growth rate of energy production from renewable resources in EU27

%		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hydropower	1,2	0,3	0,6	0,6	0,7	0,5	0,4	1,1	0,5	1,0	0,9
Geothermal	31,8	9,4	9,9	11,6	12,0	9,7	14,2	12,3	13,3	10,2	12,6
Solar total	298,4	34,3	21,2	18,4	14,7	14,3	14,1	13,1	12,6	11,9	12,1
Solar	1308,6	51,0	25,9	18,5	14,6	12,9	12,0	10,9	10,4	10,2	10,0
PV	1260,9	42,6	20,9	15,8	14,0	11,9	11,3	10,3	9,7	9,1	8,7
CSP		290,7	78,1	38,1	21,3	15,4	16,3	14,4	13,9	15,1	15,5
Solar	113,4	14,0	13,7	18,2	14,7	16,7	17,8	16,6	16,1	14,6	15,1
Marine	-6,4	0,2	14,5	13,6	15,2	14,9	107,1	55,8	35,7	33,7	28,6
Wind total	135,8	15,6	13,6	13,6	12,2	10,8	10,4	10,3	10,2	8,5	9,0
Onshore	134,1	14,0	10,7	9,4	9,2	8,3	6,5	6,5	7,2	5,5	6,9
Offshore	351,0	41,8	53,9	56,7	33,8	25,1	29,0	25,6	20,4	17,5	20,1
Heat pump	553,0	16,9	14,9	10,3	10,2	10,5	11,0	10,5	10,9	10,1	11,9
Biomass	22,2	4,2	4,0	4,4	4,0	4,2	4,4	4,6	4,5	5,2	4,6
RES	268,8	13,4	8,2	3,2	6,1	6,5	6,4	11,0	6,6	6,1	11,6
Total RES	38,7	6,7	5,8	5,4	5,4	5,4	5,7	6,4	5,9	6,0	6,7

RES Electricity

The RES electricity installed capacity in EU 27 in 2005 was 167 GW and in 2010 is increased by a factor of 1.4 having a CAGR of 8.2%. The leading countries in RES electricity installed capacity in 2010 were Germany with 53.8 GW, Spain with 39.2 GW, France with 28.8 GW, Italy with 27.6 GW and Sweden with 20.2 GW having a contribution of 68.2%. In 2020 Germany has projected to double the RES electricity installed capacity reaching nearly 111 GW representing 23.3% of the total RES electricity installed capacity. In 2020 Spain will reach 63.8 GW followed by France with 57.3 GW, Italy and UK with the same RES electricity installed capacity 43.8 GW representing 43.9% of the total RES electricity installed capacity.

Table 3. Additional RES electricity total installed capacity (GW)

			2005-2010		2010-2020	
2005	2010	2020	Additional	Share of 2005(%)	Additional	Share of 2010 (%)
167,7	248,8	475,7	81,2	48,4	226,8	91,2

The leading countries with highest additional RES electricity installed capacity in 2020 will be Germany (57.1 GW), UK (29.1 GW), France (28.6 GW), Spain (24.5 GW) and Italy (16.3 GW). In 2010 hydropower had the highest share in RES electricity installed capacity with 45.7% followed by wind with 34.4%, solar with 10.4%, biomass with 9.1%, geothermal 0.3% and marine with 0.1%.

Wind energy is projected to have the highest share in RES electricity installed capacity in 2020 with 44.3%, followed by hydropower with 26.8 %, solar with 18.9%, biomass 9.2%, marine 0.5% and geothermal 0.3%.

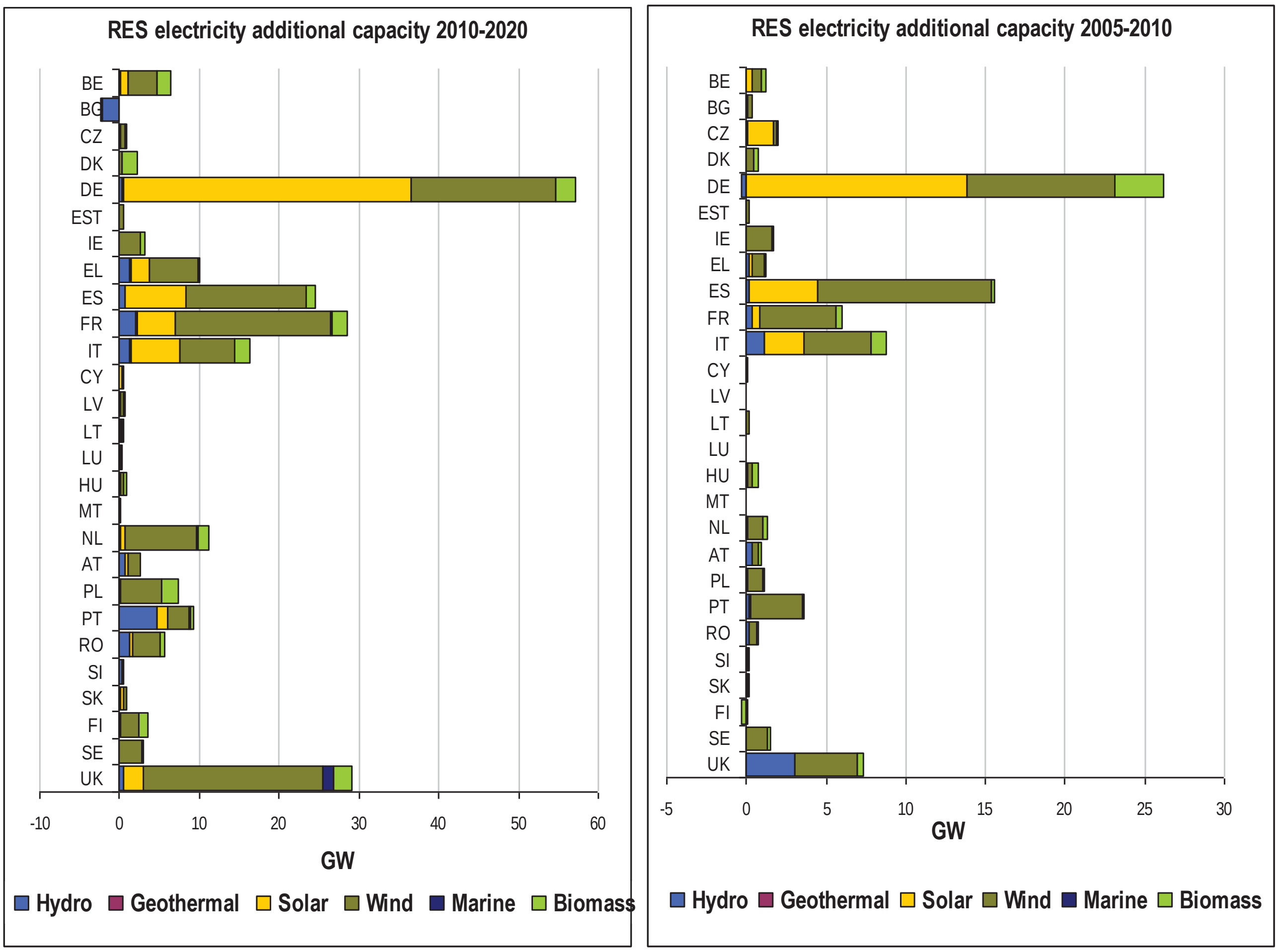


Figure 2. Additional RES electricity capacity growth between 2005-2010 and 2010-2020

In the additional electricity installed capacity between 2005 and 2010 the onshore wind has the highest share with 52.7% followed by PV with 28.4% and biomas with 8.6%. Between 2010 and 2020 the onshore wind share in additional electricity capacities will be 37.8% followed by PV with 25.9% and

biomass with 9.5%. The increase of additional CSP installed capacity between 2010 and 2020 compared with the increase between 2005 and 2010 will be with a factor of 6. (Figure 2)
The generation potential of renewable electricity in 2005 was 482.6 TWh (1737.6 PJ) and in 2010 was 34% (647 TWh or 2329 PJ)) higher with a CAGR of 6% and a yearly growth rate of 6.7%. In 2020 the RES electricity generation potential is projected to be 1203 TWh (4331.2 PJ) representing 34.1% of the electricity production in EU 27. (Table 4)

Wind energy will have the highest share in RES electricity generation in 2020 with 40.6%, followed by hydropower with 30.1%, biomass 19.5%, solar 8.3%, geothermal 0.9% and marine 0.5% (Figure 3).

Table 4. Resource share in RES electricity in NREAPs for EU27

	2010					2020				
	RES		**% of**			**RES generation**		**% of**		
	PJ	TWh	RES el	total RES	electricity	PJ	TWh	RES el	total RES	electricity
	1223	339,7	52,52	21,1	10,3	1305	362,6	30,1	12,6	10,3
	21,5	5,98	0,9	0,4	0,2	39,2	10,89	0,9	0,4	0,3
Solar	74,5	20,70	3,2	1,3	0,6	361	100,38	8,3	3,5	2,8
PV	72,0	20,00	3,1	1,2	0,6	293	81,40	6,8	2,8	2,3
CSP	2,52	0,7	0,1	0,0	0,0	68,3	18,989	1,6	0,7	0,5
Marine	1,80	0,5	0,1	0,0	0,0	23,4	6,5	0,5	0,2	0,2
Wind	597	165,9	25,6	10,3	5,0	1759	488,6	40,6	17,0	13,9
Onshore	563	156,4	24,2	9,7	4,7	1261	350,5	29,1	12,2	9,9
Offshore	31,	8,66	1,3	0,5	0,3	491	136,54	11,3	4,8	3,9
Biomass	410	114,1	17,6	7,1	3,5	8431	234,2	19,5	8,2	6,6
RES el.	2329	647	100,0	40,1	19,6	4331,2	1203,1	100,0	41,9	34,1
Total RES	5808					10336,7				
Electricity	1186					12695				

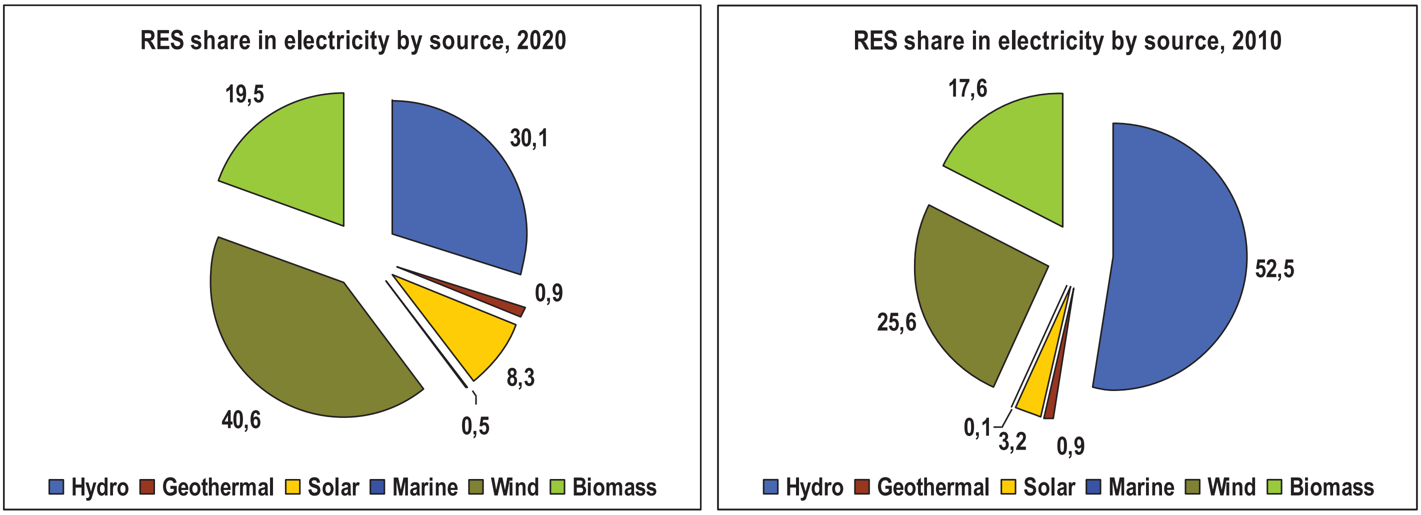


Figure 3. RES share in electricity generation in source break down

In 2020 Germany will be the leading Member State in the electricity generation from RES with 781 PJ representing 18 % of the total RES electricity in EU 27. France with 559 PJ followed by Spain with 521 PJ, UK with 421 PJ and Sweden with 350 PJ will represent in 2020 42.8% of the total RES electricity generation potential in EU 27.

RES Heating & Cooling

RES in Heating and Cooling sector in 2010 has presented the highest share in the gross final energy consumption with 46.0% (545.3 Mtoe) and is projected to remain in the leading position even in 2020 with 521.7 Mtoe with a contribution of 44.2%.

In RES heating and cooling in 2020 biomass is projected to be the largest contributor with 81% followed by heat pumping with 11% and solar thermal with 5.7 %. The contribution of heating and cooling in RES for the target year is forecasted to be 45.1% (111.3 Mtoe). The development of RES heating and cooling in absolute and relative terms is presented in Table 5.

Table 5. Resource share in RES heating and cooling generation

	2010				2020			
	RES H&C	% of			RES H&C	% of		
	in PJ	RES H&C	total RES	H&C	in PJ	RES H&C	total RES	H&C
Geothermal	28,8	1,01	0,5	0,13	110,1	2,36	1,1	0,5
Solar	61,6	2,16	1,1	0,27	265,8	5,70	2,6	1,2
Biomass	2590,	90,92	44,6	11,3	3775,2	81,01	36,5	17,3
Heat pump	168,1	5,90	2,9	0,74	508,8	10,92	4,9	2,3
RES H&C	2848,	100,0	49,0	12,4	4659,9	100,0	45,1	21,3
Total RES	5808,				10336,			
H&C	22.82				21.841			

Biomass is projected to have the highest contribution in the heat and cooling sector with 80.9% in 2020 starting from a higher contribution in 2010 with 91%. The updated analysis reveals that biomass generation potential in heating and cooling sector in 2020 is 1.4 times higher than in 2010 but the contribution in the generation will be decreased by 10%. (Figure 4).

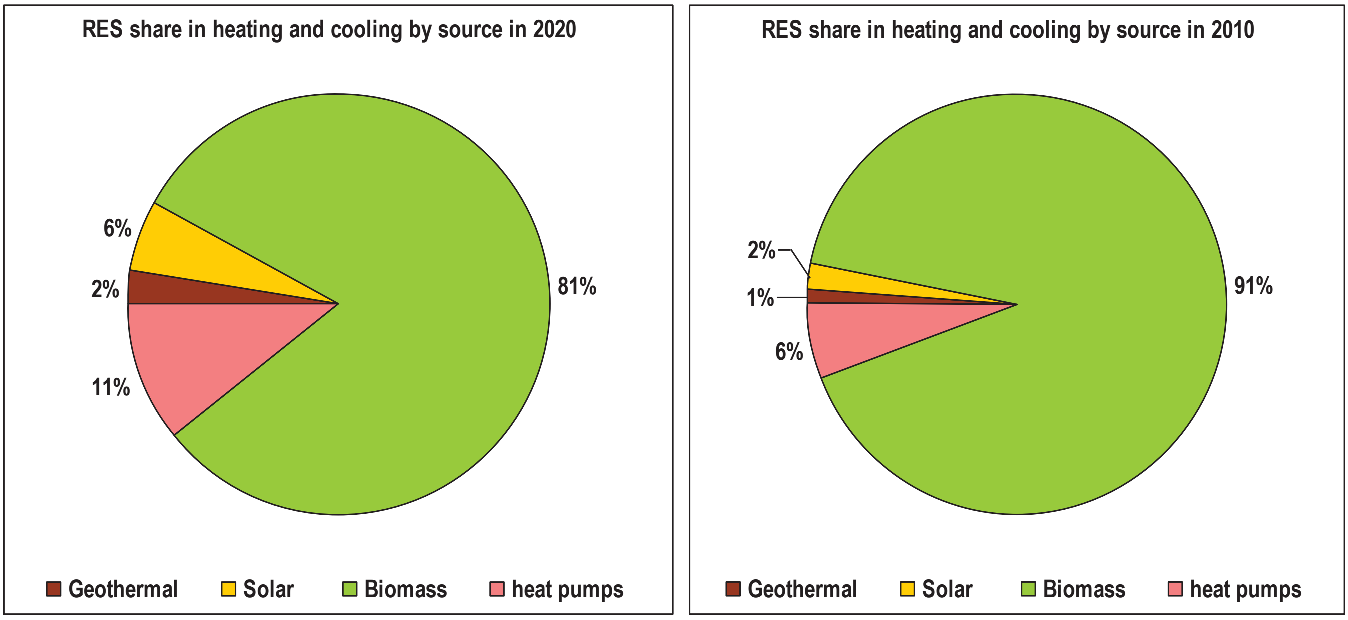


Figure 4. RES share in heating and cooling in source break down

Heat and pump will follow biomass in 2020 with 10.9% (12.1 Mtoe) together with solar with 5.7% (6.3 Mtoe) and geothermal with 2.4% (2.6 Mtoe). The increase of solar energy in 2020 compared to

2010 will be 4.3 times from 61.6 PJ to 265.8 PJ having a CAGR of 15.7%. The geothermal energy in 2020 will be 3.8 times more than in 2010, the share increased from 1 % to 2.4 % having a CAGR of 14.4%. Heat pump is tripled between 2010 and 2020 with a share almost doubled, from 5.9 to 10.9 % having a CAGR of 11.7%.

France was the leading MS in 2010 with the highest H&C generation from RES 11 Mtoe and in 2020 will be still the leading country in the generation with 826 PJ (almost 20000 ktoe) which represents the 17.7 % of the total RES H&C in EU27. The generation in the heating and cooling sector for Germany, Italy and Sweden in 2020 will be more than 10 Mtoe with a contribution of 31.8%. Together with Spain, UK, Poland and Finland the contribution of these 8 MS will represent 72% of the total heating and cooling generation potential in EU 27 for 2020.

RES Transport

The contribution of the transport sector in the gross final consumption in 2005 was found to be equal to 25.5 % (311.5 Mtoe) and in 2020 will be 26.5% (313 Mtoe) with a decrease of 0.2% compared to 2010.

The share of the transport sector within the RES is projected to be 13.0% in 2020 (32.1 Mtoe). The contribution of the transport in sectoral consumption for 2020 is projected to be 11.1%. In order to reach the 2020 target the compound annual growth of this sector is projected to be 7.9%.

The development of the RES transport according to the NREAP-s in absolute and relative terms is summarized in Table 6.

Table 6. Resource share in RES transport

	2010				2020			
	RES transport generation	**% of**			**RES transport generation**	**% of**		
	in PJ	RES transpor	total RES	transport	in PJ	RES transport	total RES	transport
Bioethanol/	119,9	19,0	2,06	0,91	305,9	22,7	3,0	2,33
Biodiesel	446,8	70,8	7,69	3,40	873,4	64,9	8,4	6,67
Hydrogen	0	0	0,00	0,00	0,1	0,007	0,0	0,00
Renewable	54,3	8,6	0,94	0,41	135,0	10,0	1,3	1,03
Others	8,8	1,4	0,15	0,07	31,1	2,3	0,3	0,24
RES transport	629,9	100	10,84	4,80	1345,5	100	13,0	10,27
Total RES	5808,2				10336,7			
Total transport	13125,1				13103,5			
RES transport adjusted to the target	658,3				1549,3			

The total contribution of RES in 2020 in the EU without double counting will be 1345.5 PJ (32.757 Mtoe). The contribution with multiple counting of electricity use in road transport and article 21.2 biofuels) in 2020 will be 1549.3 PJ (36.476 Mtoe) representing 11.8% of the energy use in the transport sector which is above the 10% binding target.

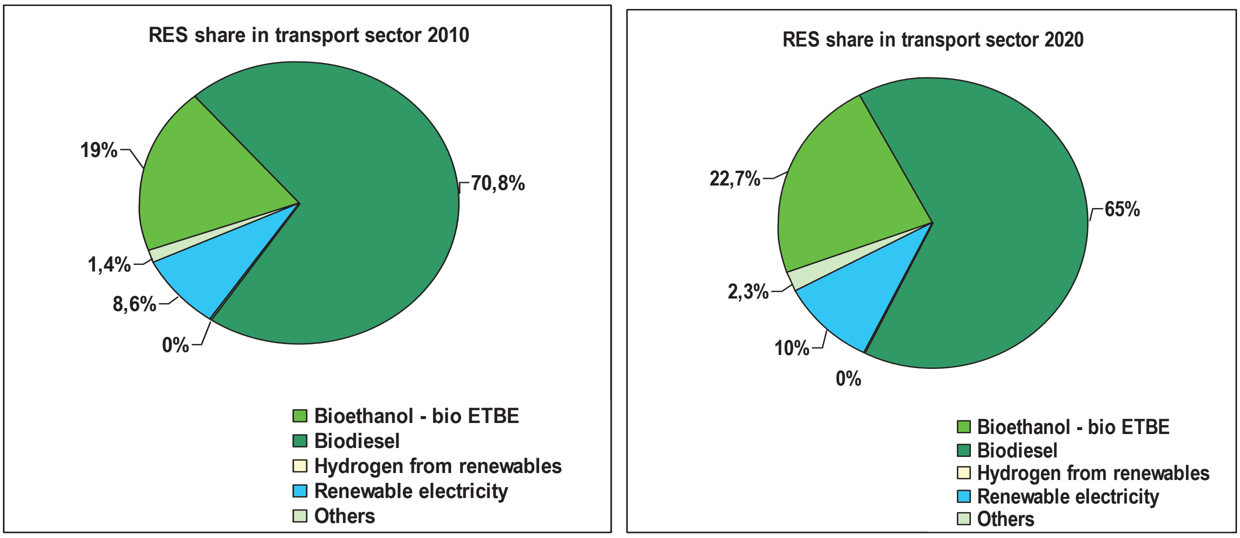


Figure 5. RES transport by source breakdown in 2010 and 2020

In 2010 the RES share was dominated by biodiesel with 70.8% and bioethanol with 19%. The renewable electricity had a contribution equal to 8.6 % (1.3 Mtoe). In 2020 it is projected that biodiesel will still dominate the sector with 65% (20.9 Mtoe), from which 24.1% will be imported. Bioethanol is following biodiesel with a contribution of 22.7% (7.3 Mtoe) together with renewable electricity which will increase up to 10 % (3.2 Mtoe) (Figure 5).

Wind

The wind energy installed capacity in 2020 according to NREAPs is forecasted to increase with a factor of 2.5 from 2010 reaching the amount of 211 GW and having a CAGR of 9.4%.

The leading EU 27 countries in wind installed capacity in 2020 will be Germany with 45.8 GW followed by Spain with 35.8 GW, UK with 27.9 GW, France 25 GW and Italy 12.9 GW. These MS will represent 31% of the total RES installed capacity. These MS will have the highest additional growth in 2020 compared to 2010

Estonia has projected to have in 2020 the highest wind share within RES installed capacity with 98% followed by Ireland with 91%. Belgium, Greece, Cyprus and Lithuania will have a wind share within renewables installed capacity higher than 50% and Malta, Netherland, Poland and UK higher than 60%.

The contribution of wind in RES electricity generation will change from 10.3% in 2010 to 17% in 2020. The contribution of wind in final electricity consumption in the target year is forecasted to be with 13.9% (1759 PJ). Yearly growth rate of wind in the total generation potential will decrease from 15.6% in 2010 to 9% in 2020.

The highest wind share within RES generation potential in 2020 will be in Ireland with 86% followed by Estonia with 80.3%. Denmark, Estonia, Malta, Netherland and UK will have a wind share within renewables electricity generation potential higher than 50%.

In 2020 the contribution of the leading MS in the electricity generation potential will be 28.7% due to Germany with 104.4 TWh, UK with 78.2 TWh, Spain with 72.6 TWh,France 57.9 with TWh and Netherland with 32.4 TWh.

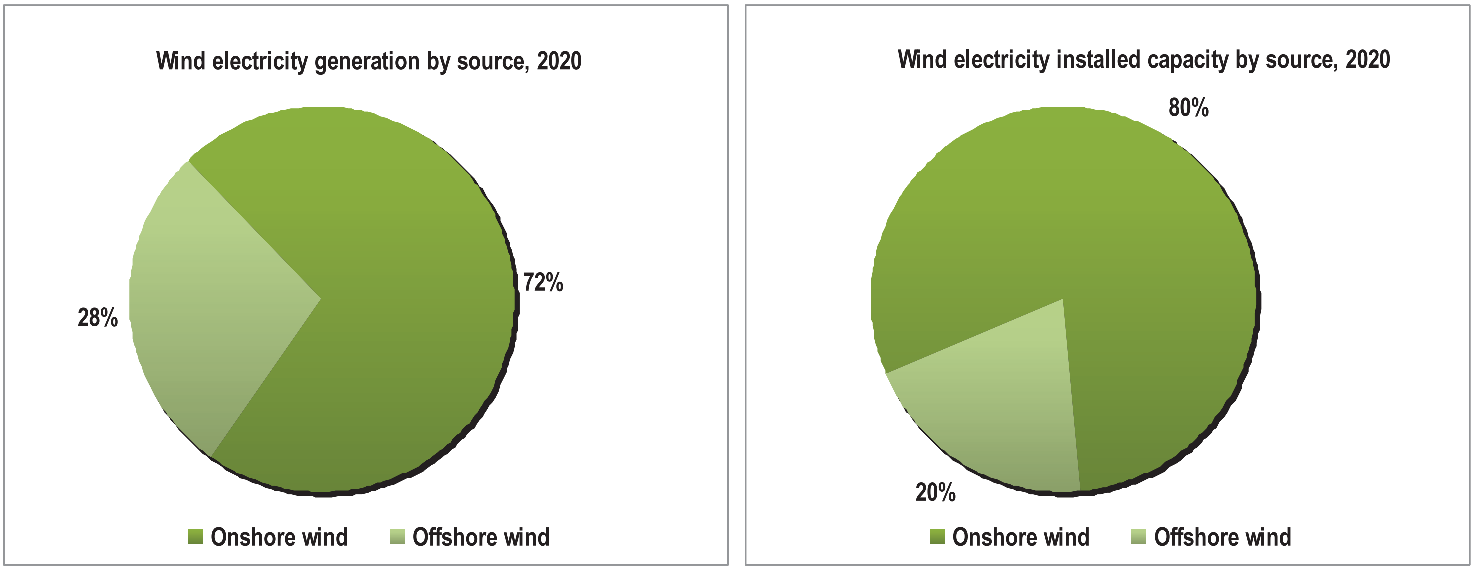


Figure 6. Onshore and Offshore wind contribution in total wind, 2020

The contribution of offshore wind in total RES generation potential in 2010 was 0.5% (8.6 TWh) and in 2020 is projected to increase by a factor of nearly 16 (136.5 TWh) representing 28% of the wind generation potential, 11.3 % of the electricity generation potential and 4.8% of the total generation potential. (Figure 6).

The highest offshore wind share within renewables electricity generation in 2020 will be in Malta with 46.1% followed by Netherland and UK with almost 38% and Estonia with nearly 30%. Malta will have in 2020 the highest wind share within renewables installed capacity with nearly 57% followed by Estonia with 38%, Netherland 34% and UK with almost 30%. Among renewables electricity technologies the offshore wind has the second highest share in the total generation potential with 41.8% which reach the maximum in 2013 with 56.7%. In 2020 the offshore wind share in total generation potential will be 20.1%.

The onshore wind installed capacity changes from 82.5 GW in 2010 to 168 GW in 2020 remaining the main contributor to the total RES generation potential with 12.2% (350.5 TWh) with a yearly growth rate of 6.9%. The contribution of onshore wind in RES electricity generation in 2020 is projected to be 29.1% (1261 PJ) representing nearly 72% of the total wind electricity generation potential having a CAGR of 8.4 %.(Figure 6)

Germany and Spain will present the highest onshore wind energy production by 2020 with 72.7 TWh and 70.7 TWh representing 40.9% of the total onshore wind electricity generation potential. Together with France with nearly 40 TWh, UK with 34 TWh and Italy with 18 TWh these MS will represent 67 % of the total onshore wind energy (Figure 7).
Ireland will have in 2020 the highest onshore wind share within renewables electricity generation with 73.5%. Estonia and Greece will have a share higher than 50% and Spain, Cyprus, Lithaunia and Portugal higher than 40%. The highest onshore wind share within RES installed capacity in 2020 will be found in Ireland with 80.1% followed by Estonia with 60.8%. Spain, Cyprus, Lithaunia and Poland will have a share higher than 50%.

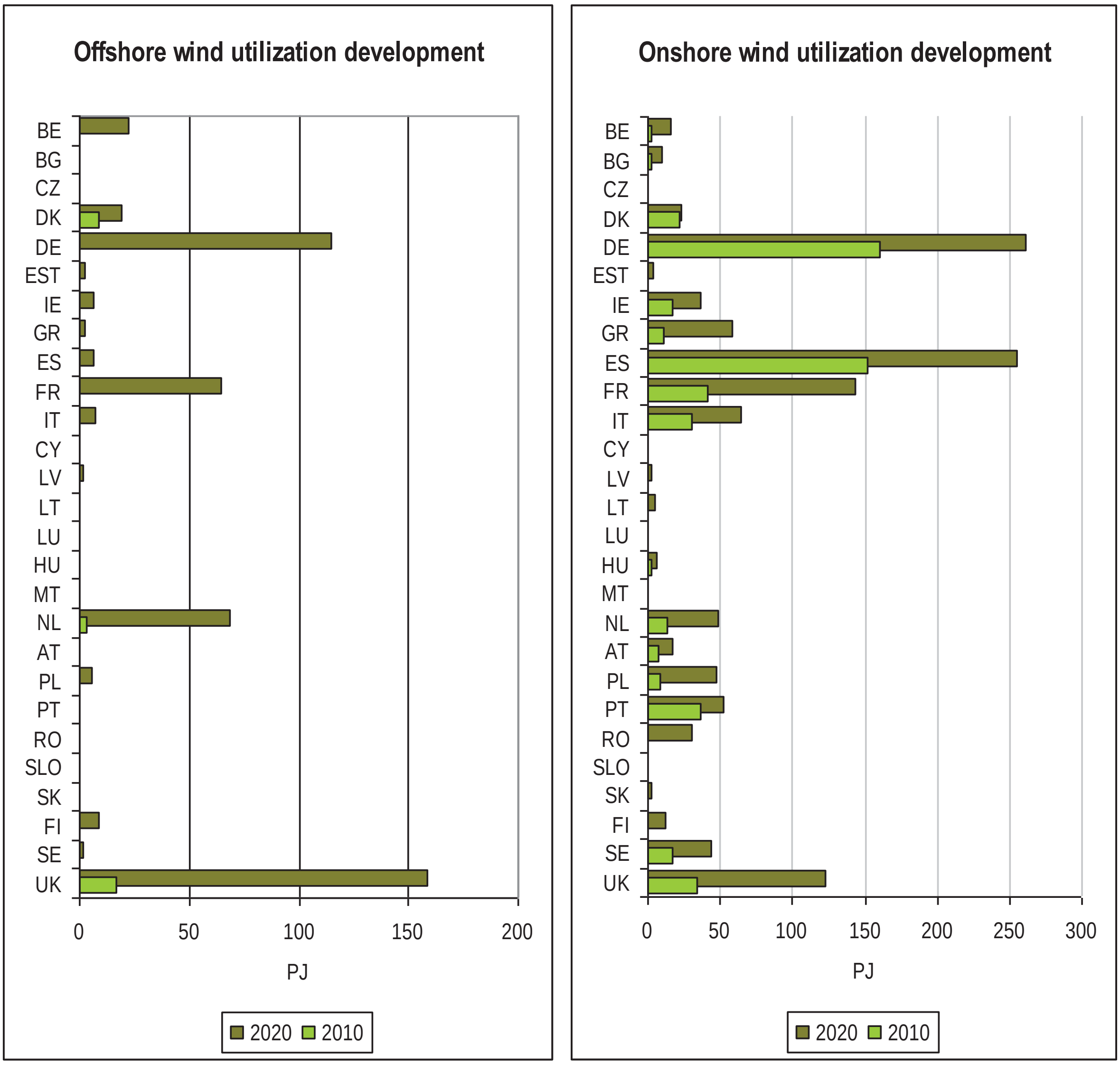


Figure 7. Offshore and Onshore wind utilization development in EU 27, 2010-2020

Biomass

According to the NREAPs the biomass is projected to have the highest contribution in the heat and cooling sector with 80.9% in 2020. The contribution of biomass in the electricity installed capacity will remain almost constant to 9% from 2010 to 2020.

The contribution of biomass in the total RES generation potential will change from 51.7% (833.5 TWh) in 2010 to 44.7% (1283 TWh) in 2020 having a CAGR of 4.4%.

The contribution of biomass in electricity generation will change from 17.6 % (114 TWh) in 2010 to 19.5 % (234 TWh) in 2020 having a CAGR of 7.5%.

The main contributor in electricity biomass is solid biomass the contribution of which in installed capacity and generation potential is 68 % respectively, followed by biogas with 28% contribution in installed capacity and 27% in generation potential (figure 8).

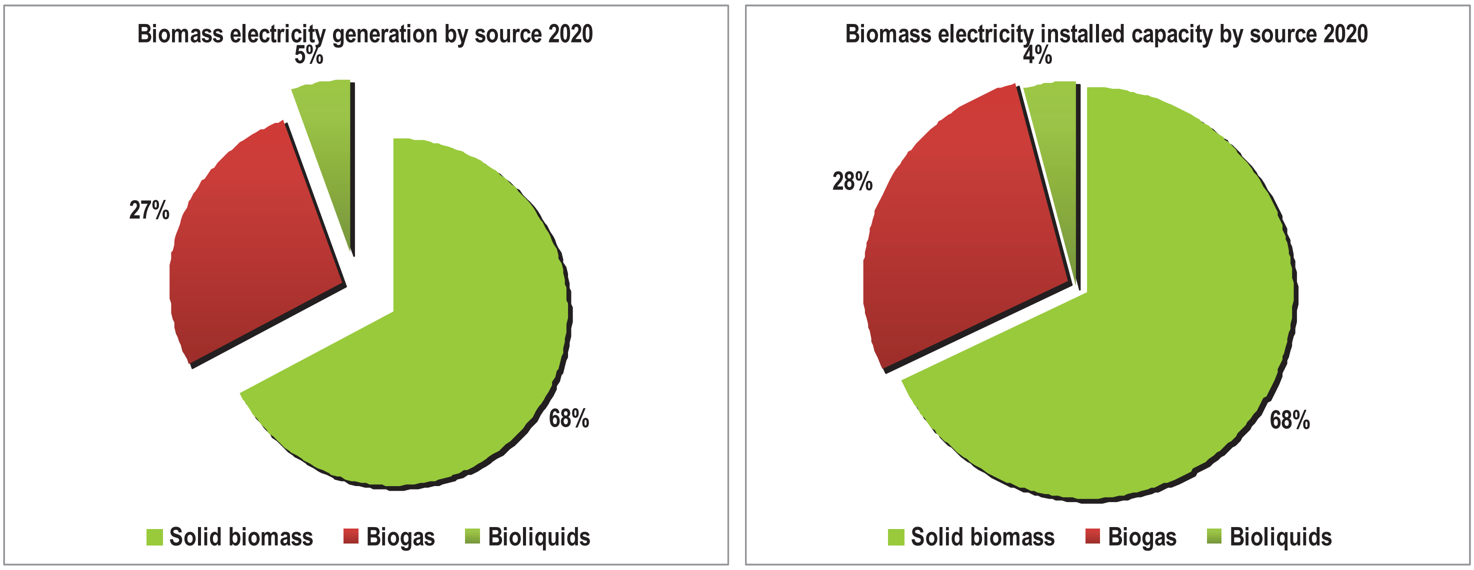


Figure 8. Solid biomass, biogas and bioliquds contribution in total electricity biomass, 2020

The biomass contribution in total RES electricity generation in 2005 was 69TWh (248.5 PJ) and in 2010 was 3.5% with 114 TWh or 410 PJ (65.2% higher compared to 2005). In 2020 the contribution of biomass in total RES electricity generation potential will increase up to 234 TWh (843.1 PJ) representing 6.6% of electricity generation.

In 2020 the contribution of Member States in installed capacity referring biomass will be 52.3% where in the leading position will be Germany with 8.8 GW followed by UK with 4.2 GW , Italy 3.8 GW , France 3 GW and Finland with 2.9 GW. In 2020 Germany with 49.5 TWh (178 PJ), UK with 26.2 TWh (94.2 PJ), Italy with 18.8 TWh (67.6 PJ), France with 17 TWh (61.8 PJ) and Sweden with 16.7 TWh (60.3 PJ) the same Member States will be in the leading position with 53% of the total electricity generation potential.

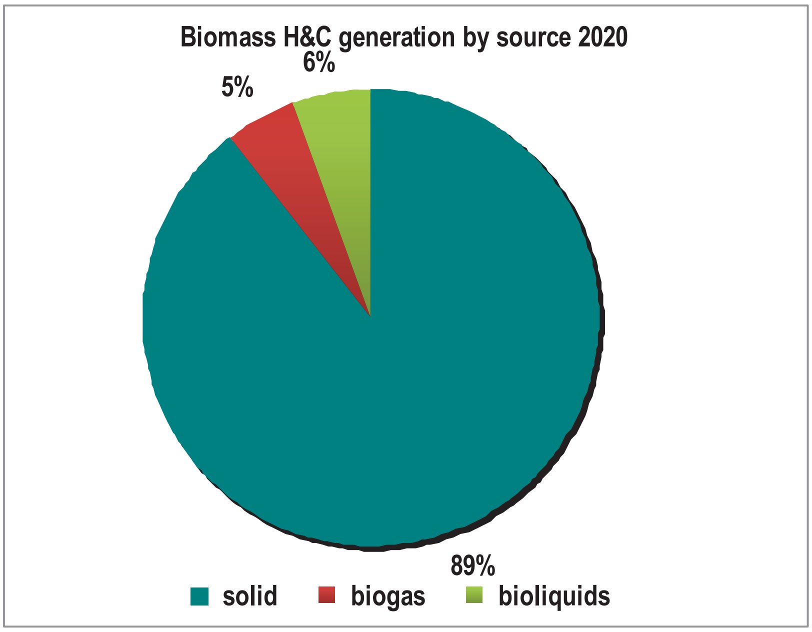


Figure 9. Biomass Heating and Cooling generation by source, 2020

The highest biomass share within renewables electricity installed capacity in 2020 will be in Denmark with 41% followed by Hungary and Finland with 39% and 34% respectively. Belgium, Lithuania and Poland will have a share higher than 25%. In 2020 the highest share of biomass within renewables electricity generation potential will be found in Hungary with 59% and Czech Republic with 52%. Belgium, Denmark, Lithuania, Luxemburg and Poland have projected to have a share higher than 25%.

The main contributor from biomass in heating and cooling sector is the solid biomass with 83.3% (61.2 Mtoe) in 2010 which is projected to decrease up to 72.5% (91.2 Mtoe) in 2020 representing 89% of the biomass in this sector. Biogas and bioliquids will contribute in 2020 in the heating and cooling sector with 4.0% and 4.5% representing 5% and 6& of the biomass in this sector (Figure 9).

France will be the leading MS in 2020 with the highest heating and cooling generation from biomass with 16.4 Mtoe. Germany will follow with 11.3 Mtoe and together with Sweden with 9.5 Mtoe these three countries have a contribution to the total generation from heating and cooling with 33.2%.

According to NREAPs biofuels will present in 2020 a contribution to the total RES mix equal to 11.7% (28.9 Mtoe or 1210 PJ) having a CAGR of 7.7% compared to 2010. The yearly average growth of biofuel will change from 13.9% in 2010 to 11.5% in 2020 being characterized by a not stable decrease.

Germany will be the highest contributor in the total biofuel generation with 5.4 Mtoe. Together with UK with 4.2 Mtoe, France with 3.6 Mtoe and Italy with 2.5 Mtoe these MS will present 54.8% of the total biofuel generation potential (Figure 10). (*Others include even the renewable electricity).

According to NREAPs the amount of biofuels that should be imported in 2020 to reach the 10% binding target will be 10.0 Mtoe presenting 34.1% of the total biofuels that will be used that year.

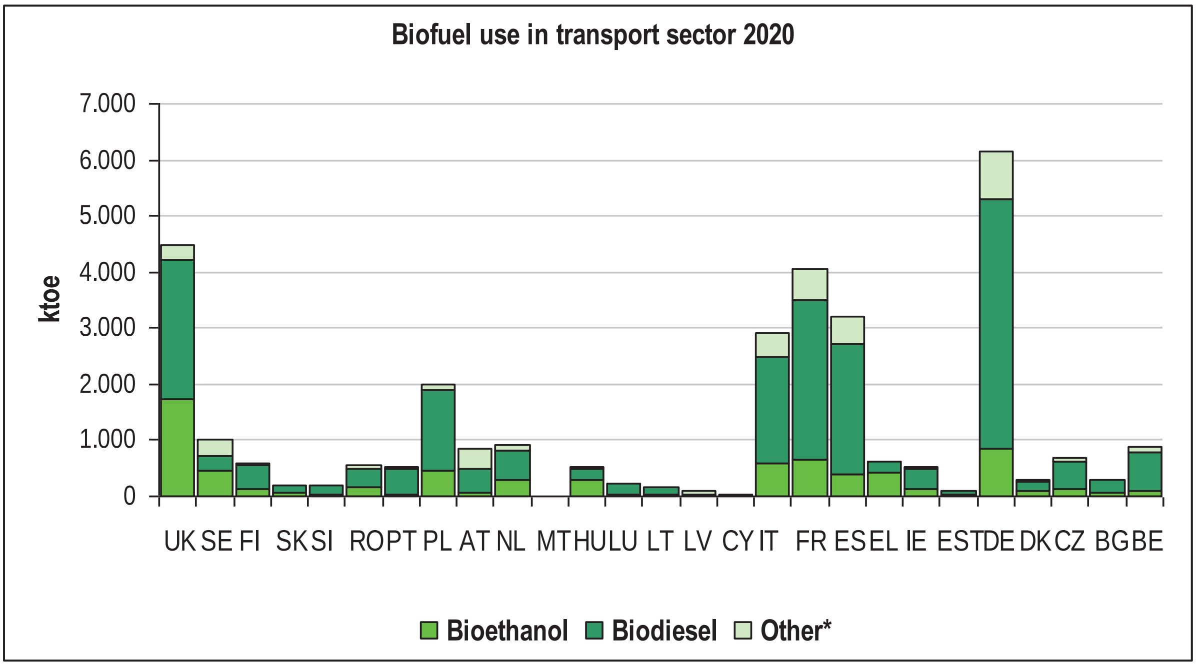


Figure 10. Biofuel use in transport sector, 2020

Marine

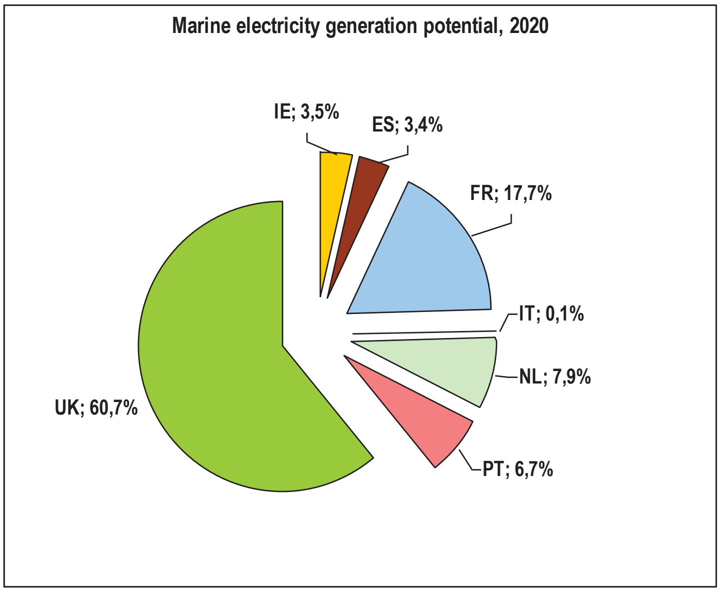
The installed capacity of marine in 2005 and 2010 was 240 MW and 245 MW. In 2020 is projected that the marine energy installed capacity will be 2243MW which represent 0.5% of the total installed capacity in EU 27 having an increase with 89.1% compared with 2010.

The marine energy generation potential in 2005 and 2010 was 535GWh (1.9 PJ) and 501GWh (1.8 PJ). By 2020 the marine energy generation potential will increase with 92.3% due to the significant increase in Portugal with 99.8% and in France with 56.5%.

The marine reported in EU 27 by 2020 is projected to be 6506 GWh (23.4 PJ), which represents 0.2 % of the total RES generation potential. Between 2010 and 2020, the amount is projected to increase with a factor of 13 with a compound annual growth rate (CAGR) of 29.2%.

Six countries, UK, France, Portugal Ireland, Spain and Italy, reported production in marine energy by 2020. The highest amount will be in the UK and France with 3950 GWh (14.2 PJ) and 1150 GWh (4.1 PJ) respectively; these two countries will represent the 78.4% of the total marine energy production in EU 27, UK alone the 60.7% (Figure 11).

In 2020 UK, Ireland and Portugal will have the highest marine energy share within the renewable electricity, with 3.4%, 1.7% and 1.2 %; UK and Ireland will have the highest marine share within the total renewable sources (RES) in 2020 with 1.6% and 0.9 % (Figure 11).



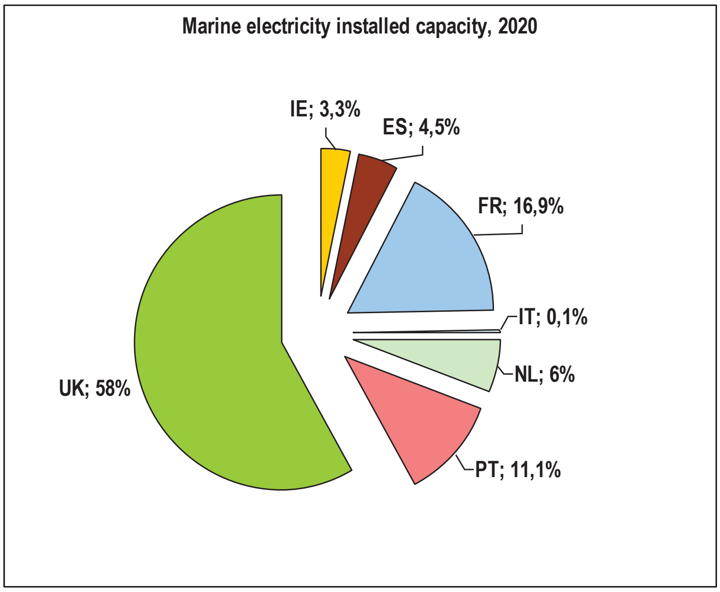


Figure 11. Contribution of MS in marine electricity installed capacity and generation potential, 2020

UK and France will have the highest share in installed capacity, generated potential and gross final energy consumption in 2020. The biggest relative change in marine energy, compared to 2010, is expected in Portugal and Spain.

Solar

This technology will have the fastest growing in electricity installed capacity in 2020 compared to 2010 by a factor of nearly 3.5, from 26 GW to 90 GW. The electricity generation potential in 2020 will be increased from 20.7 TWh (74.5 PJ) that was in 2010 to 100.4 TWh (361.4 PJ). The compound annual growing rate of solar installed capacity and electricity generation potential in 2020 compared with 2010 will be respectively 13.3% and 17.1%.

Solar total generation in 2020 will reach 174.2 TWh from 37.8 TWh (136.2 PJ) that was in 2010. Solar in total will represent 6.1% of the total RES mix in 2020 from 2.3% contribution in 2010. The contribution of solar electricity in the total solar will be 57.6% and 3.5% in the total RES mix (Figure 13).

The solar photovoltaic installed capacity in 2020 will be 83 GW meaning that the contribution of solar photovoltaic installed capacity represents 2.1% of the total solar capacity that can be installed in EU (3887GW).

In 2020 the leading countries in solar installed capacity are projected to be Germany, Spain, Italy, France and UK with respectively 51.8 GW, 12GW, 8.6GW, 5.4GW and 2.7GW. The capacity installed in these countries will present 89% of the solar installed capacity and 16.9% of the total RES installed capacity in EU

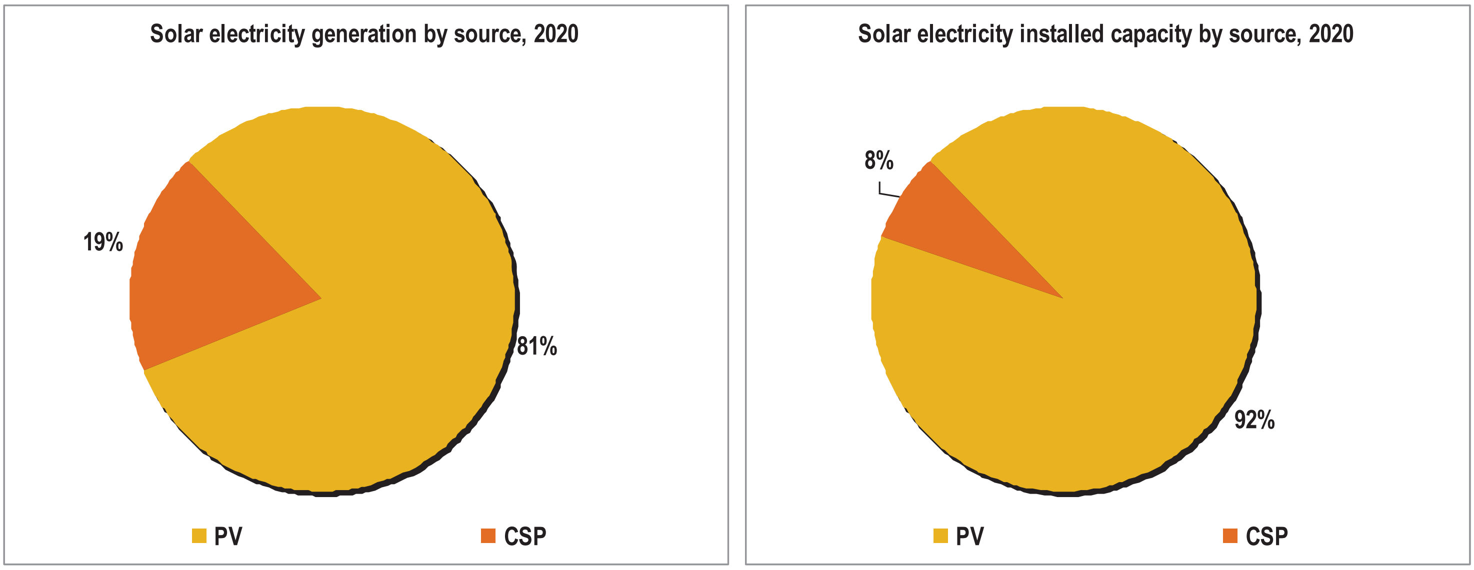


Figure 12. PV and CSP in solar electricity installed capacity and generated potential in EU 27, 2020

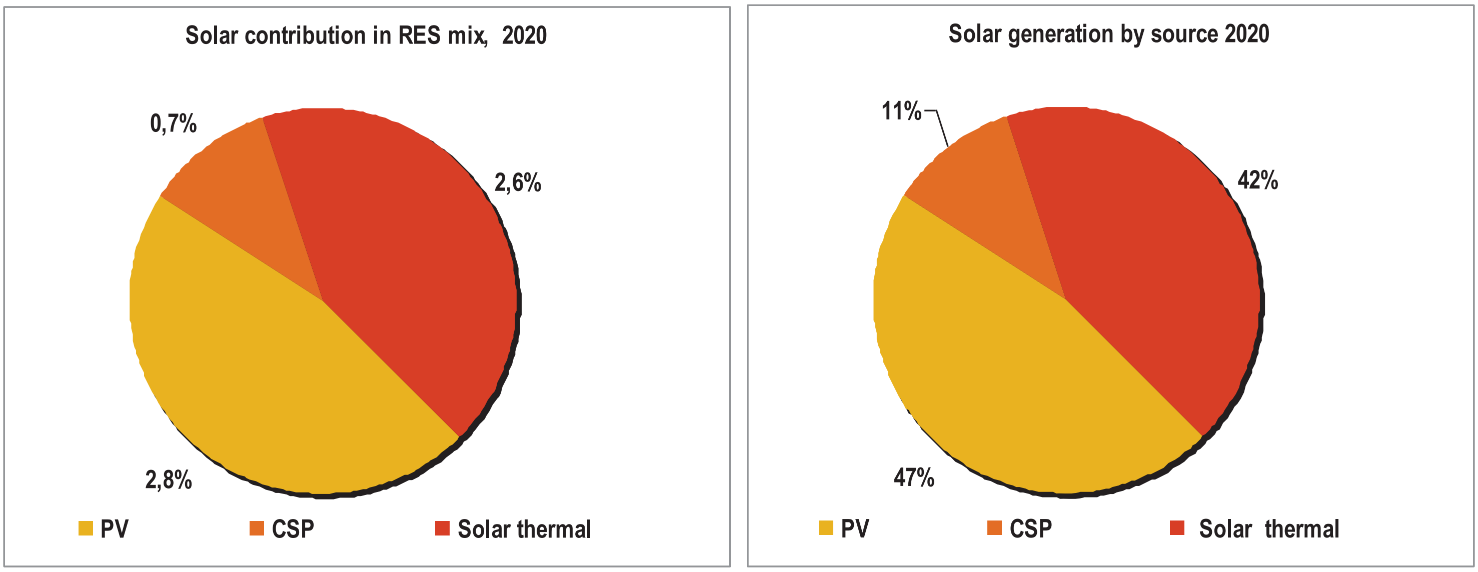


Figure 13. PV, CSP and Solar thermal in generated potential and RES mix by source, 2020

PV is the main contributor in the solar electricity installed capacity and generation potential with 92% and 81% respectively (Figure 12). PV will remain the main contributor in the total solar with 47% 8293 PJ) in 2020 followed by solar thermal with 265.8 PJ. The contribution of PV, CSP and solar thermal in RES mix in 2020 will be 2.8%, 0.7% and 2.6% respectively (Figure 13).

In 2020 the leading countries in electricity generation potential will be Germany, Spain, Italy, France and Greece with 41.4 TWh (149 PJ), 26.7 TWh (96.2 PJ), 11.4 TWh (40.9 PJ), 6.9 TWh (24.8 PJ) and 3.6 TWh (13 PJ) respectively representing 7.7% of the total RES electricity generation and 5.7% of the total RES generation potential in EU. These MS will represent in 2020 89.6% of the total solar electricity generation potential in EU 27.

The highest solar share within the renewables electricity generation in 2020 will be found in Cyprus with 45.4 % followed by Spain and Germany with 19.8% and 19.1 %. Czech Republic, Greece and Italy will have respectively 15%, 13.2% and 11.5%.

The highest solar share in renewables electricity installed capacity in 2020 will be in Germany with 46.7%, Cyprus with 45.7%, Czech republic with 43%, Luxemburg with 32.6%, Italy with nearly 20% and Spain with 19%.

The highest PV share within renewables electricity generation potential in 2020 will be in Cyprus with 26%, Germany with 19% and Czech Republic with 14.8%. In renewables electricity installed capacity the highest share of PV in 2020 will be in Germany with 46.7%, Czech Republic with 43%, Cyprus with 32.9% and Luxemburg with 32.6%.

Germany will represent in 2020 62% of the total PV installation capacity with 51.8 GW and 50% of the total PV generation potential with 41.4 TWh (149 PJ). Spain (7.3 GW), France (4.9 GW), Italy (8 GW) and UK (2.7 GW) will contribute to the total PV installation capacity with 27%. Spain and Italy will follow Germany in the contribution to the total PV installation capacity with 12.3 TWh (44.5 PJ) and 9.7 TWh (34.7 PJ) respectively.

CSP energy is projected to have an increase in 2020 in the generation potential by a factor of 27 compared to 2010, from 0.7 TWh (2.5 PJ) to 19 TWh (68.4 PJ) having a CAGR of 39% and a yearly growth rate of 15.5%.

The CSP generation share reported in the NREAP will reach the 19.0 % of solar electricity generation potential by 2020 and the share of the RES electricity 1.6 %. By 2010 the CSP technology is present only in Spain with an amount of 0.7 TWh (2.5 PJ) and Italy with 9 TWh (0.03 PJ). In all the other Member States the technology is later introduced. In 2020 Spain will increase the generation from this technology with a factor of 21 reaching 14.4 TWh (51.8 PJ) representing 76% of the total generation potential from CSP.

The highest CSP share within the renewables electricity is in Cyprus and Spain with 19.1 % and 10.2%.

RES share and trajectory

The RES Directive developed the “cooperation mechanism” which allows countries to transfer virtually their surpluses or deficits to each other. The NREAPs forecast that the EU 27 in 2020 will exceed 20% Renewable Energy Consumption Target with 0.75%. From the NREAPs analysis it can be expected that probably each year the EU will reach a net surplus also in the interim period until 2020. According to NREAPs Italy has projected to have the largest deficit among MS with 1.1Mtoe. UK, Finland, Estonia and Romani have projected a very small deficit in 2020. Germany has projected a domestic surplus in 2020 of around 3 Mtoe followed by France with 1 Mtoe. Other MS have projected not so high values for the surplus in 2020 (Figure 14).

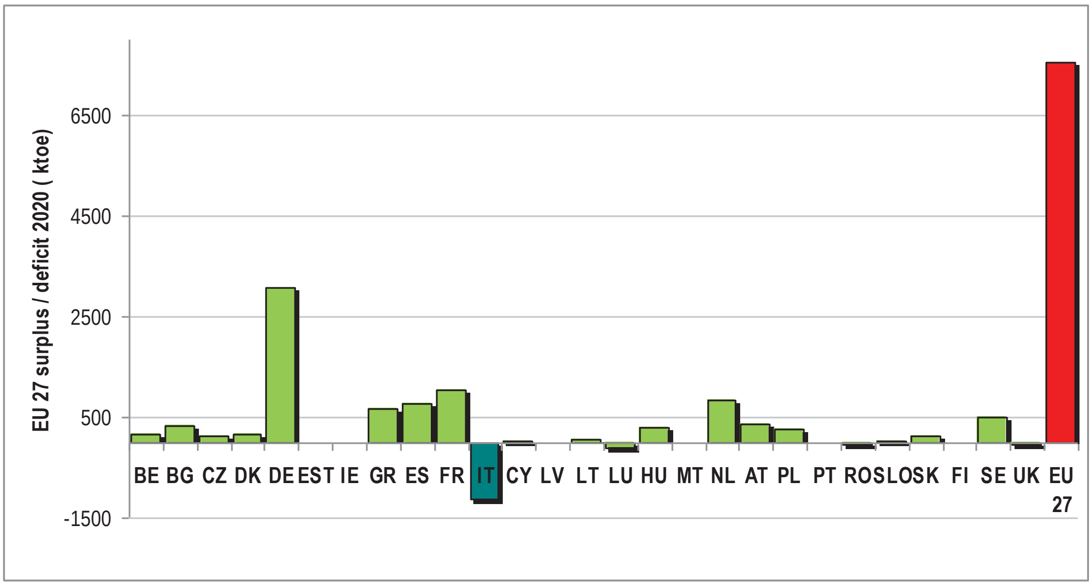


Figure 14. EU 27 surplus/ deficit development 2020

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Abstract

Penetration and deployment of renewable energies in Europe is analyzed on the basis of the latest available data and statistics.

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